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14. ABSTRACT

The primary goal of the Acquisition Review Quarterly (ARQ) is to provide practicing DoD Acquisition, Technology and Logistic Professionals with relevant management tools and information based on recent advances in policy, management theory, and research. The ARQ addresses the needs of professionals across the full spectrum of defense acquisition, and is intended to serve as a mechanism for fostering and disseminating scholarly research on acquisition issues, for exchanging opinions, for communicating policy decision, and for maintaining a high level of awareness regarding acquisition management philosophies.

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ACQUISITION

Review

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LESSONS LEARNED

In October 2000, the Secretary of Defense announced that a new policy of "evolutionary acquisition" would become the preferred approach to acquiring defense systems. Implementation of the new policy has been far from automatic. Today — two years after issuance of the evolutionary acquisition policy — the Department continues to struggle to adopt a consistent approach to policy implementation, but also to achieve the kind of lasting cultural change that is critical to long-term policy success. The roots of this implementation struggle are explored, paying particular attention to the concept of policy ambiguity and how such ambiguity can drive organizational conflict. Organizational conflict is inevitable, but not necessarily counterproductive. In fact, the original policy can be improved as the organization undergoes an iterative process of interpretation, conflict, and refinement.

This case study explores the development of the Patriot PAC-2 and its historic deployment in the Gulf War from the vantage point of five senior technical managers. In addition to in-depth interviews with these senior managers, U.S. Army Aviation and Missile Command (U.S. Army Command) historical documents, unclassified government reports, and other public sources were reviewed for information regarding PAC-2 development. Patriot PAC-2 is a case study in effective project management that resulted in the extraordinary acceleration in the final stages of development, production, and deployment in time to play a historic role in the Gulf War. The Patriot PAC-2 lessons may benefit future project managers engaged in the final stages of system development prior to a major conflict.

literature, data collected through interviews with eight faculty course development managers, and data analysis to correlate findings with the research literature. The study indicates that many of the success factors found in the literature were also important to management of the DAU course development projects. A number of additional success factors identified were important for the DAU courses and may be important for other distance education development environments. Recommendations for development managers of distance education courses are proposed.

A NOTE FROM THE EXECUTIVE EDITOR

This is my final issue as the executive editor of the *Acquisition Review Quarterly* journal. And since I came on board February 2001, I have seen the journal evolve and even undergo a facelift and formatting changes which went into affect in the publication of our Summer 2002 edition.

It has been my pleasure to serve as chairman of the editorial board and executive editor of the *ARQ*. I am also pleased to provide comments regarding the issue that you now hold in your hands — the Winter 2003 edition of the *ARQ*.

The first article explores the struggles associated with the implementation of acquisition policy. In "Conflict and Ambiguity: Implementing Evolutionary Acquisition," the authors describe the difficulty of implementing policy, even for policy-like evolutionary acquisition, which has been part of acquisition strategy for decades. The insights gained from the conclusions of this article should serve to help others in both policy formulation and policy implementation.

Also in this edition, we discover the results of a number of technology-based initiatives. How the systems we acquire perform in the field is of paramount concern, especially systems highly dependent on advanced technologies. In "Lessons Learned from the Development of the PAC-2 and the Deployment in the Gulf War," the author shares the experiences of technical and program managers involved in the implementation of the Patriot missile during the Gulf War. The publication of this article is timely especially as we face the imminent possibility of another conflict with Iraq.

The influence of technology is not just limited to the development and deployment of major weapon systems, but it has always played an important part in supporting the missions of our nation's intelligence agencies. This is even more evident today in the wake of 9-11. In "The CIA's In-Q-Tel Model for Military Systems," the author describes how the CIA is attempting to identify and use new technologies to maintain the level of national security which is at the core of their mission.

Technology has literally changed the face of our educational system and in "Program Planning of Asynchronous Online Courses: Design Complexities and Ethics," the writer tackles the elusive issue of creating an on-line environment by incorporating a natural, critical learning environment. This is essential to the success of any course, whether classroom or online, but is most difficult to achieve in the on-line environment. The article should be of special interest to readers responsible for the design and development of on-line courses.

Another aspect of distance learning is addressed in "Managing Development of Technology-Based Courses: Success Factors from Eight Government Training Courses," the authors sought evidence for the existence of critical success factors for distance

learning. In their findings they conclude not only that critical factors exist, but also have been identified, which may not have been considered by others implementing distance learning, both in government and in private universities.

I do hope you enjoy this issue of *ARQ* as much as I have enjoyed being associated with the journal. I want to thank the staff, referees, and authors for their dedicated support of this publication.
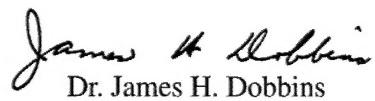
Dr. James H. Dobbins

Winter 2003

CONFLICT AND AMBIGUITY
IMPLEMENTING EVOLUTIONARY ACQUISITION

Richard K. Sylvester and Joseph A. Ferrara

In October 2000, the Secretary of Defense announced that a new policy of "evolutionary acquisition" would become the preferred approach to acquiring defense systems. Implementation of the new policy has been far from automatic. Today — two years after issuance of the evolutionary acquisition policy — the Department continues to struggle to adopt a consistent approach to policy implementation, but also to achieve the kind of lasting cultural change that is critical to long-term policy success. The roots of this implementation struggle are explored, paying particular attention to the concept of policy ambiguity and how such ambiguity can drive organizational conflict. Organizational conflict is inevitable, but not necessarily counterproductive. In fact, the original policy can be improved as the organization undergoes an iterative process of interpretation, conflict, and refinement.

The Department of Defense (DoD) continues to struggle in their implementation of a new policy for "evolutionary acquisition" to acquire defense systems. The roots of this implementation struggle are explored here, paying particular attention to the concept of policy ambiguity and how such ambiguity can drive organizational conflict. The more ambiguous a policy is, the more likely it is that the various institutions charged with implementation will emphasize their particular institutional perspectives in the policy process. And when these institutional perspectives clash, organizational conflict is inevitable, but not necessarily counterproductive. In fact, the original policy can be improved as the organization undergoes an iterative process of interpretation, conflict, and refinement.

First, the history of evolutionary acquisition and its adoption as official DoD policy is reviewed, then the literature on policy implementation, focusing on ambiguity and conflict. Next, how the ambiguity of the evolutionary acquisition policy has affected the key institutions involved in implementation is explored, and how these institutions have filled in the blanks with their own judgments and conclusions about how the policy should work. We conclude by trying to determine

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if the messy process of policy implementation under conditions of high ambiguity helps produce a better and stronger policy.

POLICY IMPLEMENTATION

During the 1970s, in their search for what went wrong with President Lyndon Johnson's Great Society programs, political scientists discovered implementation. Scholars, pundits, and citizens alike were disappointed by the obvious gap between Johnson's soaring rhetoric in the mid-1960s about a "war on poverty" and the feeble results the anti-poverty programs seemed to be producing when evaluated a decade later. A new public policy approach grew up within political science to establish a connection between classical administrative theory and the new policy landscape wrought by the social and political transformations in postwar America (Kettl, 1993). The connection was implementation. Implementation was the "missing link" between policy formulation and adoption, and actual policy outcomes (Hargrove, 1975).

"No new policy is self-executing or completely self-explanatory."

Starting with Pressman and Wildavsky's study (1973) of the Economic Development Administration's work on community development in Oakland, California, the stage was set for an outpouring of books and articles focusing on policy implementation as a crucial determinant of policy success. Indeed, the literature was growing so quickly that one writer observed that the problem with implementation research was not too few explanatory variables, but too many (O'Toole, 1986). By the 1990s, the scholarly literature on implementation had ballooned to immense proportions.

In response to this scholarly "overgrowth," several researchers began attempts to synthesize the burgeoning implementation literature (Goggin, 1990). The results of this synthesis project pointed to a much smaller, much more manageable set of variables that might potentially explain the relative ease or difficulty encountered during the implementation process. Three factors in particular stood out for special attention: ambiguity, conflict, and institutional perspectives (Goggin, 1990; Matland, 1991; Pressman & Wildavsky, 1973; Sabatier, 1999). It might be argued that in this framework, ambiguity is the key factor driving the level of conflict and the variance in the perspectives that various institutions adopt.

No new policy is self-executing or completely self-explanatory. There is sure to be some degree of ambiguity about the policy and its objectives. Some will ask what the new policy means in terms of overall organizational goals. Others will point to specific cases and ask whether and how the new policy applies. The greater the degree of ambiguity — the more questions people have about the meaning and direction of a new policy — the more likely the implementation process will be a bumpy ride.

Similarly, the issuance of any new policy is sure to inspire conflict. Not everyone will agree with the new policy. Some may flatly oppose it. Others may simply be unsure of whether it is the best solution for the problem at hand.

And some will try to modify the policy's intent to meet their own institutional agendas. As with ambiguity, the greater the conflict inspired by the new policy, the more heated the political discussion becomes. And if the policy is itself highly ambiguous, or at least perceived that way by key institutional actors, then conflict is almost inevitable. Not surprisingly, this has important consequences for how smoothly implementation proceeds.

Finally, the degree of conflict and ambiguity a new policy inspires is, in part, a function of the institutional perspective one brings to bear. Is one operating within the bureaucracy, or outside, say, on a legislative staff, or with a government-contracting firm? Mile's Law is pertinent here — where one stands often does depend on where one sits.

Even the bureaucracy itself is no monolith. Within its walls are many different functional groupings — budget and financial analysts, middle managers, policy analysts, project managers, operators; the list literally goes on and on. And each of these bureaucratic divisions practices a special trade; comes out of a particular intellectual and institutional tradition; holds certain values and makes certain assumptions; and defines its mission somewhat uniquely — all of these factors help shape a particular institutional perspective, a lens through which new policies are received, understood, and, ultimately, judged. Over time, the way each organization interprets and implements the new policy creates new precedents and generates lessons learned. Thus, the process of implementation itself becomes a way of modifying and refining the original policy (Lipsky, 1980).

POLICY BACKGROUND

In October 2000, the Defense Acquisition Executive issued a new policy governing the systems acquisition process in the Department of Defense. This policy, contained in the DoD Directive 5000.1 and its accompanying instruction, called for the DoD to adopt "evolutionary acquisition" as its preferred approach to acquiring defense systems:

> To ensure that the Defense Acquisition System provides useful military capability to the operational user as rapidly as possible, evolutionary acquisition strategies shall be the preferred approach to satisfying operational needs. Evolutionary acquisition strategies define, develop, and produce/deploy an initial, militarily useful capability (Block I) based on proven technology, time-phased requirements, projected threat assessments, and demonstrated manufacturing capabilities, and plan for subsequent development, production, and deployment of increments beyond the initial capability over time (Blocks II, III, and beyond). (Department of Defense [DoD], Directive 5000.1, 2000, p. 4)

The DoD Instruction 5000.2 (2000) further discusses the application of evolutionary acquisition:

> Evolutionary acquisition is an approach that fields an operationally useful and supportable capability in as short a time as possible. This approach is particularly useful if

software is a key component of the system, and the software is required for the system to achieve its intended mission. Evolutionary acquisition delivers an initial capability with the explicit intent of delivering improved or updated capability in the future. (DoD, 2000, p. v)

Recently, DoD issued streamlined interim guidance (Wolfowitz, 2002) in place of the DoD 5000 documents signed in 2001. The interim guidance will be replaced by updated DoD 5000 documents within the next 120 days. In the interim guidance, evolutionary acquisition continues as the Department's preferred acquisition strategy. However, DoD has now published a model for evolutionary acquisition (Figure 1).

Despite its recent DoD endorsement, evolutionary acquisition (EA) was by no means a new concept in the defense community. Indeed, it had been discussed and debated for many years — at least as far back as the early 1980s — prior to its ultimate adoption in October 2000 as official DoD policy.

In 1983, for example, the Armed Forces Communications and Electronics Association (AFCEA) published a study of EA that focused on its applicability to command and control systems. In 1984, the Joint Logistics Commanders (JLC), the three and four-star heads of the Services' logistics commands, formally endorsed evolutionary acquisition as a legitimate strategy and asked the Defense Systems Management College (DSMC) to produce a guide.
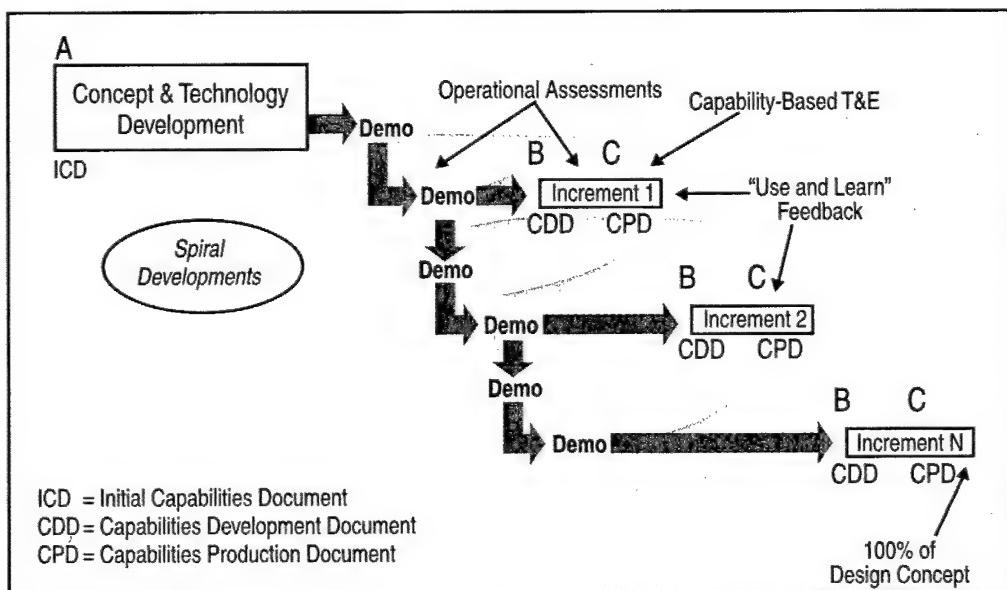
Figure 1. Evolutionary Acquisition and Spiral Development

Three years later a guide was co-published by DSMC and the JLC. The JLC guide, following the AFCEA study, focused on Command and Control (C2) systems although it stated, "while this guidance is aimed specifically at the use of an EA strategy in acquiring Command and Control systems, the principles discussed may also be applicable to the acquisition of other kinds of systems" (Joint Logistics Commanders [JLC], 1987, p. v). The JLC guide offered this general description of an EA strategy: "Considered most broadly, EA consists of first defining the general outline of an overall system, and then sequentially defining, funding, developing, testing, fielding, supporting and evaluating increments of the system" (JLC, 1987, p. v).

Also during this period, the software development community began to publish articles and research briefs advocating a form of evolutionary acquisition, most typically referred to as spiral development. Probably the single most influential article was Barry Boehm's 1988 piece in the journal *Computer* entitled "A Spiral Model of Software Development and Enhancement." Boehm sketched out a development approach whose main characteristics included concurrent engineering, risk-driven determination of process and product, early elimination of non-viable alternatives, and an evolutionary process of experimentation and elaboration that resulted in successively refined prototypes. Boehm's graphical depiction showed a line representing the development process that emanated ever outward in a series of spiral loops (hence the name "spiral" development).

Various industry associations had also endorsed the concept of evolutionary acquisition. During the 1990s, for instance, the National Center for Advanced Technology (NCAT), an industry research group affiliated with the Aerospace Industries Association, published a suggested evolutionary model and met with various DoD officials to recommend its official adoption. In a February 1996 letter to the Principal Deputy Under Secretary of Defense, NCAT specifically recommended what it called an "evolutionary defense acquisition" model:

> Existing DoD-5000 phases could be replaced with a process using 3 to 5 years to develop and field systems in step with modern technology cycles. It would focus on mainstream U.S. defense needs into the next century, including precision weapons, C3I, information warfare, and technology upgrades to existing [major platforms]. The new process would be called "evolutionary defense acquisition" (EDA), stressing an intent to change today's culture with an affordable, incremental approach (National Center for Advanced Technology [NCAT], 1996, p. 3).

"Also during this period, the software development community began to publish articles and research briefs advocating a form of evolutionary acquisition, most typically referred to as spiral development."

Even the Defense Acquisition Executive (DAE) issued guidance on the use of evolutionary strategies during this period in a memorandum published in January 1995. The DAE memorandum recognized evolutionary acquisition as a legitimate strategy and endorsed it as

an "alternative" practice to be assessed by program managers on a case-by-case basis. Here the DAE was clearly following the tenor of the prior studies and guides, many of which characterized EA as an acquisition strategy most appropriate for command and control software-intensive systems. (NCAT — in its "evolutionary defense acquisition" model, published a year after the January 1995 DAE "EA-as-an-alternative-approach" — was probably the first institution to call for the broader use of EA).

In 1998, DoD embarked on a series of high-level management improvement studies, collectively referred to as the "Section 912" studies (after section 912 of the Fiscal Year 1998 National Defense Authorization Act, which called for the studies). These studies provided the final intellectual push justifying EA as an appropriate acquisition strategy for a department contending with the twin revolutions in military and business affairs (the "RMA"[1] and "RBA,"[2] respectively).

> **"EA, it seemed, was the perfect strategy for meeting the challenges of RMA and the RBA."**

EA, it seemed, was the perfect strategy for meeting the challenges of RMA and the RBA. The RMA emphasizes highly sophisticated defense capabilities based on the latest advances in information and communication technologies, the generational cycles of which are typically measured in months, not years. Since EA stresses an incremental approach to development, which capitalizes on the best mature technologies available at a given point in time, it matched up well with the rapid technology cycles implicit in acquiring RMA systems.

Meanwhile, the RBA highlights the need to revolutionize DoD's management systems to achieve more efficient, less costly decision and oversight processes. Again, EA appeared to match these objectives very well, since it promises an approach that would dramatically reduce cycle time and, because it relied on an intensive team-based approach to developing requirements and acquisition strategies, would reduce the costs of oversight. The Section 912 studies strongly recommended EA and then-DAE Jack Gansler enthusiastically endorsed this finding. Soon after, DoD formed a dedicated working group to revise the DoD 5000 series in line with the new EA approach.

The concept of evolutionary acquisition is not new — as we have seen, various individuals and institutions have been arguing for its adoption for at least 20 years (Figure 2). These arguments have all emphasized one key advantage to its use — the potential for dramatic reductions in cycle time (the time it takes to move from initial development of a program to actually delivering an operationally effective and suitable product to a user). In addition, its advocates have argued that EA makes sense for a technology-intensive defense environment characterized by ever more sophisticated capabilities and rapid generational cycles. It all seems clear but, as we argue below, the EA policy is fundamentally ambiguous in a few important respects.

IMPLEMENTING EVOLUTIONARY ACQUISITION

The DoD's ongoing process of implementing an evolutionary approach to systems acquisition provides a useful

1983 – AFCEA Study of Evolutionary Acquisition (EA) for C2 Programs

1986 – Joint Logistics Commanders Endorse EA

1987 – DSMC and JLC Publish a Guide for EA Programs

1988 – Boehm Article on Spiral Development

1990 – JLC/DSMC Recommend that EA Language be Included in 5000 Regulations

1995 – DAE Issues Guidance on the Use of EA

1996 – NCAT Recommends EA as Preferred Approach to Acquisition

1999 – Section 912 Study Team Endorses EA Approach

1999 – Chairman, JCS Endorses Time-Phased Requirements

2000 – DoD Publishes New 5000 Regulations Endorsing EA as Preferred Approach

Figure 2. Evolution of a Policy Concept

case study for analyzing the role of ambiguity, conflict, and institutional perspective in policy implementation.

AMBIGUITY

A good policy is one that clearly articulates not only the desired outcomes the policy maker is seeking to achieve through the issuance of the policy but also the means by which those expected to implement the policy can make it a reality. A policy that lacks clarity in purpose and clarity in implementation creates ambiguity in the bureaucracy, and ambiguity is one thing bureaucracies try to avoid at all costs.

The evolutionary acquisition policy is one that on its face lacks clarity. DoD has long built systems in an incremental fashion. The Air Force's F-16, for example, was developed in the early 1970s and has been upgraded with block modifications over the last three decades. DoD has had a policy of pre-planned product improvement (P3I) for some time. When the DoD Instruction 5000.2 announced the new evolutionary acquisition policy,

many people within DoD asked if the policy was anything new or just old wine in new bottles — a new, fancy name for an old way of doing business.

To add to this confusion, DoD leaders have used different terms when talking about EA. For example, when Pete Aldridge, the new Under Secretary of Defense for Acquisition, Technology and Logistics USD(AT&L), began discussing the use of mature technology to develop systems that meet only a portion of the requirements initially, but that would be further developed over time based on new technologies and revised user requirements, he called this process "spiral development" (harkening back to the Boehm article — indeed Boehm himself published a more recent article, in 2001, arguing that "some ambiguities in previous spiral model definitions have also led to a good number of unsuccessful projects adopting 'hazardous spiral look-alikes.'" [Boehm & Hansen, 2001]). Not surprisingly, the reaction of many observers — in DoD and in the Congress — was to ask whether there is

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a difference between evolutionary acquisition and spiral development, and, if so, what the difference is and what it means.

In fact, this ambiguity was so great that the USD(AT&L) was compelled to issue a clarifying memorandum on April 12, 2002 to define the terms evolutionary acquisition, spiral development, and pre-planned product improvement:

> Since the publication of DoD Directive 5000.1 and DoD Instruction 5000.2, in which the Department established a preference for the use of evolutionary acquisition strategies relying on a spiral development process, there has been some confusion about what these terms mean and how spiral development impacts various processes such as contracting and requirements generation that interface with an evolutionary acquisition strategy... Evolutionary acquisition and spiral development are similar to pre-planned product improvement but are focused on providing the warfighter with an initial capability which may be less than the full requirement as a trade-off for earlier delivery, agility, affordability, and risk reduction. (Aldridge, 2002, p. 1)

Despite the issuance of this memorandum, questions still persist: How will evolutionary acquisition be implemented in contracts? How will evolutionary systems be supported? How will they be funded? Recently, the office of Secretary of Defense, together with industry, has formed a team to develop a Web-based continuous learning module to address the growing demands for clarity and an end to the ambiguity surrounding the EA policy.

Because EA has never been implemented in a wholesale fashion within the DoD, no one is exactly sure of how its implementation will play out, but everyone is pretty sure that full implementation of EA, as called for in the 5000 series, will probably mean major changes to the way DoD has traditionally done business. In a recent article, Alexander Slate (2002) outlines the numerous consequences of implementing an EA policy. These consequences include more upfront work being necessary; a greater role for acquirers in the requirements process and a greater role for requirers in the acquisition process; and a new approach to budgeting. Among other things, these consequences will alter established organizational relationships and such shifts almost always lead to conflict.

CONFLICT

One of the major issues in government (indeed, in all organizations) is who has power and who does not. The framers of the U.S. Constitution were so concerned with this issue that they devised a governmental structure that decentralized power so that it could not be concentrated in the hands of any one branch or organization. Shifts in power are a primary cause of conflict within government and particularly within the bureaucracy. New policies often have the affect of changing the power relationship because new policies add or reduce authority, or shift authority from one organization or person to another. The issuance of a new policy is often the occasion

for the recalibration of organizational relationships. The more a policy shifts power, the more conflict is engendered by that policy (particularly if the policy is itself also highly ambiguous).

When DoD made EA the preferred approach to acquisition, there was a significant change in the power relationships that heretofore had prevailed. Under the old single-step-to-full-capability model (sometimes also called the "grand design" approach) that the Department had been using over the last 30 years, the power of the acquisition community to act had been steadily decreasing. From the heyday of the Defense Research and Engineering organization in the 1970s, the power of the acquisition community to influence the course of major systems projects has been eroded by the rise of other powerful institutions within DoD.

First, and most importantly, the main hedge against the acquirers being able to develop and procure whatever they choose has been the Comptroller organization and its all-important power of the purse. The Comptroller sets rules for the release of money, and money is what fuels the engine of acquisition. Second, the Joint Requirements Oversight Council (JROC) and the requirements generation process it oversees have grown in influence and organization. The result has been a major bureaucratic entity with the power to shape acquisitions through the process of setting requirements. Finally, the establishment of the independent Director of Operational Test and Evaluation, with its authority to determine whether a system is operationally suitable and effective, has created yet another organization with the power to stop or significantly alter an acquisition.

Evolutionary acquisition changes this power balance. The process of spiral development gives the acquisition community a critical role in determining which requirements will be met when, thus creating a more collaborative relationship with the JROC. Moreover, EA also gives the acquisition community leverage against the power of the initial operational test and evaluation to determine which systems will go forward and which will stop in their tracks. Evolutionary acquisition can do this by giving the acquirers the authority to shape a system based on technology maturity and what can be produced at any given point in time, rather than what is required or what passes a test. And the more fluid and flexible process that EA envisions poses a direct challenge to the more rigid, control-oriented culture of the Comptroller community.

> "When DoD made EA the preferred approach to acquisition, there was a significant change in the power relationships that heretofore had prevailed."

Conflict is inevitable in this environment of shifting power. In fact, in recent Congressional testimony, the Principal Deputy Under Secretary of Defense for Acquisition, Technology and Logistics acknowledged as much when he said, "we recognize that we have more challenges ahead, specifically...the implementation of spiral development and other techniques to shorten the weapon system development life cycle" (Wynne, 2002).

INSTITUTIONAL PERSPECTIVES

The Department of Defense is probably the most complicated organization

in the entire federal government. Essentially a holding company for a diverse assortment of enterprises, DoD includes four military services, three military departments, 10 functional and regional combatant commands, 15 defense agencies, and a burgeoning set of policy-making and oversight institutions, including the Office of the Secretary of Defense (OSD) and the Joint Chiefs of Staff. Each of these institutions has its history, its own values, its own defining experiences, regulations, norms, and culture. Moreover, the chain of command from the Secretary of Defense and other top DoD leaders to senior managers in these various organizations can be so complex and difficult to trace that the issuance of new policies from on high is often seen as an invitation to debate rather than an order to implement. Again, this intrinsic tendency is exacerbated when the newly issued policy is perceived as ambiguous and difficult to understand.

The ultimate success of the EA policy relies fundamentally on the actions and reactions of a few key institutions within the defense establishment. These institutions include:

- *Congress*, which through the power to pass laws and appropriate money, wields ultimate power over the DoD;

- *The military departments*, the organizations charged by law with organizing, training, and equipping the military forces;

- *The defense industry*, the major contractors on whom the military relies to develop and build new weapon systems;

- *The comptroller community*, the collection of organizations throughout DoD that play the key role in the annual development and execution of the national defense budget;

- *The requirements writers and operational users*, who represent the "pointy end of the spear" and whose judgments about urgent military needs are rarely brushed aside; and,

- *The test and evaluation community*, which, through a few key statutes, possesses significant powers to pass judgment on the suitability and effectiveness of weapon systems approaching the production stage.

In Figure 3, we examine each of these communities, focusing on how they filter the ambiguity of the EA policy through the particular lens of their institutional perspective.

Congress. The Congressional role in defense management is well established in the U.S. Constitution. Article I lays out several vital Congressional powers, including the authority to "declare war," to "raise and support Armies," to "provide and maintain a Navy," and to "make rules for the government and regulation of the land and naval forces." Congress has not been shy about exercising these various constitutional powers: DoD cannot spend money without Congressional approval. The President cannot staff the higher reaches of the Pentagon bureaucracy, from the Secretary of Defense to the Service Secretaries, without Senate confirmation. Department officials cannot initiate new start programs unless Congress approves, nor can DoD officials continue programs that Congress has refused to authorize. Fundamental changes in the personnel management system cannot be implemented without statutory changes;

Institution	Key Value(s)	Perspective on EA
Congress	Holding the bureaucracy accountable	Cautious and skeptical, though concerned about budget and requirements implications and lack of control
Military Departments	Protecting important acquisition programs	Cautiously optimistic, though concerned about implications for oversight, budget, and downstream logistics
Defense Industry	Creating value and staying profitable	Cautiously optimistic, though concerned about changes in traditional approach to production contracts and follow-on competition
Comptroller	Holding programs accountable and managing the top line	Skeptical and concerned about bow wave effects of overly flexible requirements process
Requirements/Users	Getting the best technology available and keeping the edge on all potential adversaries	Cautiously optimistic, though struggling with some disconnects between headquarters and field-level perspectives
Test and Evaluation	Ensuring operational effectiveness and suitability	Skeptical about whether EA will facilitate testing comprehensive enough to ensure operational effectiveness

Figure 3. Summing up the Institutional Perspectives

indeed, the Department must even ask for permission to conduct personnel demonstrations. This far-from-complete list of Congressional authorities over defense management illustrates the key legislative value of maintaining control over the bureaucracy.

In addition to control, Congress also emphasizes bureaucratic accountability. One way of doing so is through reporting requirements. Each year Congress demands and receives large quantities of information to assist it in conducting its oversight role. From the hundreds of reports requested during each year's authorization and appropriations processes, to the permanent statutory reports, such as the Selected Acquisition Reports on major weapon system programs, the range of reporting requirements is wide and deep. Title 10 of the U.S. Code, for example, requires over 460 recurring reports each year. This is in addition to nearly 200 recurring reports required by individual Authorization or Appropriation Acts, as well as hundreds of one-time reports.

This focus on control and accountability has certainly colored the Congressional perspective on DoD's push to implement evolutionary acquisition. Indeed, a core tenet of the evolutionary acquisition approach is flexibility, particularly in the early stages of requirements generation and initial development, and this very flexibility conflicts rather directly with Congress's historical emphasis on control.

The recent report of the Senate Armed Services Committee (SASC) illustrates this conflict:

> The committee supports the Department's effort to build more flexibility into the acquisition process and develop weapon systems in more manageable steps. At the same time, the committee believes that the Department must take a more disciplined approach to incremental acquisition and spiral development to avoid losing control over the acquisition process. (Senate Armed Services Committee [SASC], 2002, p. 334)

Here the language of the Senate committee report emphasizes "discipline" and "control," neatly illustrating the conflict that exists between the Congressional and Department perspectives on evolutionary acquisition. While the Department leadership believes that evolutionary acquisition strategies will in fact give them more control over the acquisition process, in the sense of more manageability, less risk, and more rapid cycle times, Congress appears to believe just the opposite. Evolutionary acquisition doesn't necessarily mean better outcomes; rather, it raises the specter of a loss of control and discipline.

Later, the report language also exemplifies how ambiguity is affecting the policy implementation process:

> In the committee's view, the terms "incremental acquisition" and "spiral development" are not interchangeable. Incremental acquisition is an acquisition strategy of gradually improving a capability through a planned series of block upgrades, each of which is to be acquired and fielded. Spiral development is a strategy for achieving a new capability through the phased development of fieldable prototypes. The committee understands that it may take several development "spirals" before a systems is ready for production and acquisition. (SASC, 2002, p. 335)

Clearly, Congress wants DoD to develop a common language and disciplined approaches to implementing evolutionary acquisition.

Defense Industry. The modern defense industry has its origins in World War II, during which the U.S. "arsenal of democracy" mobilized to produce thousands of aircraft, ships, and tanks for the United States and its allied partners. Although there was a period of demobilization immediately following World War II, it quickly ended with the onset of hostilities in 1950 in Korea, and from that point forward, the American defense industry essentially operated on a full wartime basis (Gansler, 1996).

The end of the Cold War, signified by the 1989 fall of the Berlin Wall and the 1991 dissolution of the former Soviet

Union, had profound and immediate consequences for the U.S. defense industry. Encouraged by the Secretary of Defense and other DoD officials, the industry embarked on an aggressive round of mergers and consolidations throughout the decade of the 1990s. At the end of this period, the industry had resolved itself into a new structure with just a few major prime contractors left standing, including Lockheed Martin, Boeing, Raytheon, and Northrop Grumman. In addition to this structural turmoil, there has been immense pressure on the defense industry to achieve higher levels of civil-military integration; that is, a greater interoperability between the military and civilian sectors of the industrial base (Perry, 1994).

Similarly, the implementation of evolutionary acquisition also poses management challenges for defense firms. The impression that the defense industry forms of evolutionary acquisition will be largely a result of how this new approach comports with key industry values and norms, specifically business risk and commercial processes. That is, does the industry see evolutionary acquisition as an approach that will decrease, or increase, business risk? And does the industry see evolutionary acquisition as an approach that will fit relatively smoothly with existing commercial processes, or as one that will require significant disruption and alteration of existing processes?

Again, the ambiguity of the EA policy and its potential consequences plays a role. On the one hand, there is strong evidence that the defense industry supports the new policy. The National Center for Advanced Technology, an industry group, was one of the first organizations to call for EA as the preferred approach to defense acquisition. In addition, several recent Defense Science Board (DSB) task forces, which included industry membership, have supported a new DoD model very similar to the EA approach. A good example is the July 1999 DSB Task Force on Acquisition Reform, whose final report endorsed a streamlined acquisition process consisting of only two major decision points ("system demonstration" and "build"). This model looks very similar to the EA model DoD adopted in 2000.

Speaking at various defense conferences, other industry leaders have also endorsed the EA policy; in particular because of its emphasis on using mature technologies to bring the system design to fruition as quickly as possible. For example, the report, "A Blueprint for Action," published in conjunction with the 2001 American Institute for Aeronautics and Astronautics Defense Reform conference and co-authored by various industry leaders (DFI International, 2001), argues that "a critical area for reform will be the institution of new rules that provide for effective spiral development. This will require working outside the current acquisition model...a useful departure from this practice would be to field technologies that represent an '80 percent solution,' but which offer the war-fighter and the technologist alike a jumping-off point" (p. 16). In general, much of the industry support of the EA policy can be explained by the fact that

> **"In addition to this structural turmoil, there has been immense pressure on the defense industry to achieve higher levels of civil-military integration...."**

EA, at least in principle, mirrors the commercial process for bringing new products to market.

But there are significant question marks about how EA policy will be implemented, and these issues could affect industry support. A key issue, for example, is whether and how competition for follow-on EA blocks will be conducted. Historically, the firm that won the major development contract was in a very strong position to become the "sole-source" provider of the new system for years into the future. The new EA approach could potentially alter this relationship. While Firm A may win the contract to develop and build Block 1, it is not clear that this means Firm A will necessarily be the favorite to win the Block 2 work or even if there will ever be a Block 2.

Similarly, EA's emphasis on more upfront work and more scanning of potential alternatives, including commercial and nondevelopmental items, could also mean more competition in the defense field — a result that no doubt promises real benefits for the taxpayer but shakes up the status quo for established defense contractors.

Finally, the implementation of EA may change the value proposition for defense businesses, which have traditionally relied on high-quantity production runs as a key source of profitability. Rather than building toward such production runs after a lengthy development

> **"Finally, the implementation of EA may change the value proposition for defense businesses, which have traditionally relied on high-quantity production runs as a key source of profitability."**

cycle, EA approaches may more likely be characterized by a series of lower-rate production runs of different increments.

The Military Departments. Interservice rivalry is a staple of the defense management literature (Halperin, 1974; Wilson, 2001), but it would be wrong to conclude that the military departments do not share common bureaucratic goals. Indeed, two key objectives that all three military departments share are, first, a strong desire to get their premier acquisition programs funded, and, second, an equally strong desire not to be micromanaged by higher headquarters, in particular the OSD staff.

In this context, the potential consequences of the new EA policy are ambiguous. For one thing, just as defense firms have traditionally relied on high-quantity production runs for profits, the military departments have relied on grand-design development efforts (and the subsequent production runs) to ensure significant budget share over long periods of time. And EA strategies, with their succession of incremental designs and deliveries, may necessitate more oversight, not less. These consequences pose significant challenges for the traditional norms and objectives of the military departments. Indeed, as OSD began to develop the EA policy in 1999 and 2000, the initial reaction of the military departments was skeptical. In particular, the Army and Air Force acquisition executives then Paul Hoeper and Larry Delaney, respectively questioned the utility of the new policy, wondering if it represented, as Secretary Hoeper put it, "a bridge too far."[3]

They had various questions about the new policy — Would the investment required up front for technology scanning,

prototyping, market research, and concept development squander precious resources that would be needed later to actually build the program? How could the military departments be assured that the funding necessary for Blocks 2, 3, and beyond would actually be available when needed? And if it were not available, wouldn't that mean that the military departments would end up delivering less-than-full capability to the user, and wouldn't that damage their credibility as the institutions charged by law to "organize, train, and equip" the fighting forces?

As the EA policy has been officially adopted and a new administration has come into office, some of this skepticism has melted away. Today, all three military departments have endorsed the concept of evolutionary acquisition and are adapting it to their own cultures. The Air Force acquisition executive, for example, in interim guidance to the Air Force acquisition community (Sambur, 2002) states unequivocally that EA is the preferred acquisition *strategy* for achieving the "commander's intent" and that spiral development is the preferred *process* to execute the EA strategy. In part, this support for EA may stem from a realization that, rather than threatening all-important budget share, EA policy may preserve it as the Services pursue numerous demonstrations and development efforts to meet emerging warfighter needs. And, while it may in fact result in more oversight, EA may also mean fewer opportunities to fail because it avoids the all-or-nothing mentality of the grand-design approach.

The Comptroller Community. One of the most powerful institutions in the defense establishment is the Comptroller. Starting at the top with the DoD's Chief Financial Officer (CFO) and his staff of budget analysts and moving down through the budget offices of the military departments and defense agencies, the comptroller community has at its disposal a wide range of tools that give it enormous influence in the acquisition process. The comptroller can withhold money from acquisition budgets and write Program Budget Decisions that zero out programmed funding for one or more fiscal years. And it is the comptroller community, under the direction of the CFO, that manages the annual process of reconciling the myriad puts and takes of the Program Objective Memorandum (POM) and Budget Estimate Submission (BES) cycles to produce the defense portion of the President's Budget.

> **"A program is well-managed if every dollar can be accounted for and linked, often in excruciating detail, to specific project line items and program elements."**

Not surprisingly, given its chief role in managing budgets and finances, the comptroller community values control and accountability (Popovich, 1998). A program is well-managed if every dollar can be accounted for and linked, often in excruciating detail, to specific project line items and program elements. Conversely, free-floating "innovation funds" or "technology investments" tend to be viewed quite negatively. In this way, the comptroller community is close cousin to the Congressional appropriators. Indeed, in many ways the DoD Comptroller has historically maintained a very close relationship

with the House and Senate appropriators.

So far, the comptroller community's reaction to the EA policy has been skeptical. A major point of contention has been how to handle the transition between successive EA blocks — When does it make sense to program funds for research and development of Block 2? How will the Department ensure that the military departments will not "game" the budget process, essentially using Block 1 as a means to get an ill-defined program into the budget and thus build crucial political momentum that will be difficult if not impossible to overcome should a decision be made that the program should be cancelled. How will budgeting work at the beginning of the EA process, when a series of activities are all ongoing simultaneously — technology scanning, market research, development of alternative concepts — even though a real program has yet to be established? How will programs be "fully funded" and when if requirements are not known at program initiation and each block of capability is independently priced? Will this create a "bow wave" that will cause more instability in out-year funding?

"The EA approach emphasizes flexibility, encourages incremental strategies, and recognizes that the user may not even know what is really required."

The EA approach emphasizes flexibility, encourages incremental strategies, and recognizes that the user may not even know what is really required. All of this poses severe challenges to traditional comptroller norms and values.

The Requirements Community. Historically, the starting point for the acquisition of any new item or service has been the mission need statement followed by the definition of operational requirements (Locher, 1985; Shalikashvili, 2000). The traditional approach to the development of operational requirements has been to establish a long-range planning time frame; request that the intelligence community project the likely threats in that time frame; and analyze the relevant research effort underway in the science and technology base of both government and industry labs and engineering organizations. These analyses result in the establishment of detailed performance characteristics for a new system. In turn, the "requirements" are turned over to the acquisition community, which establishes a budget and then selects a contractor to achieve the requirements within the budget levels. The user community monitors progress toward achieving the set requirements — which are rarely changed once established.

Because the requirements process has tended to focus on achieving very ambitious technical objectives, DoD program managers have often found themselves developing systems while simultaneously having to develop the technologies that will make the systems work. The F-22, for example, was heavily dependent on fly-by-wire technology, which, at the time the system began its development, was not mature. The inevitable result has been lengthy development cycles.

In response to the 1999 Section 912 reports, the Joint Staff issued a new Chairman's Instruction (CJCS Instruction 3170.01) that adopted evolutionary, or "time-phased," requirements as standard practice for developing and writing

operational requirements. While the Joint Staff recognized the need for time-phased requirements to support evolutionary acquisition, there remains a great deal of ambiguity with regard to actual application of the Joint Staff direction.

One of the most serious concerns is determining the priority of what needs to be done first and allowing those requirements that cannot be done first (either because the technologies to support them are not mature or because the funding to support them is not available) to be moved to subsequent increments of capability. These decisions are made, not at the Joint Staff level, but at lower levels where military department officials actually write the Operational Requirements Documents (ORDs). Based on the few time-phased ORDs that have been written since the issuance of the EA policy, there is some evidence to suggest that requirements writers are hedging their bets by front-loading capabilities into the initial system increments. For example, the recent Comanche ORD was revised to include three blocks of capability. However, the first block will include up to 90 percent of the system requirements — more if there is no second block. ·

This front-loading can potentially result in conflict with the acquisition community, where expectations might be that the initial increment will be more in the neighborhood of a 50 percent solution than a 90 percent solution. As one observer recently argued, "users fear that support for programs will dry up before they get a lot of the capabilities they need" (Slate, 2002, p. 9). This fear drives front-loaded requirements documents, even though this runs counter to the new Joint Staff policy.

Thus, while there is general agreement at the top of the requirements generation system that evolutionary acquisition based on time-phased requirements makes sense, there is much that needs to be done at the implementation level of requirements generation system to actually provide requirements to the acquisition community that would make these intentions a reality.

Operational Test and Evaluation. The Director of Operational Test and Evaluation (DOT&E) oversees test and evaluation in DoD. The DOT&E organization, itself a creation of Congress, is guided by a series of statutes that require certain types of tests (e.g., live fire tests) to be conducted on certain types of systems (e.g., major programs) at certain points in the acquisition process (e.g., before proceeding beyond low-rate production). DoD program offices develop test and evaluation master plans to guide the overall testing process. The DOT&E determines the systems to be tested, how many items can be procured for testing, the requirements to be tested against, and whether or not the system is survivable, lethal, effective, and suitable (although all these judgments are subject to debate and reclama within the Department). This test and evaluation structure has been established to ensure that systems are not deployed before the Department knows how well they work.

> **"This test and evaluation structure has been established to ensure that systems are not deployed before the Department knows how well they work."**

Evolutionary acquisition changes how systems are produced and, therefore,

how they need to be tested. The testing regime is based on the idea of a grand design in which a single system will be produced, initially at a low rate, and then subject to comprehensive testing before being permitted to move to full rate production. As the Department has moved to evolutionary acquisition, the role of operational test and evaluation has become more ambiguous. Evolutionary acquisition provides multiple increments of capability, each to be deployed over time. While the need to determine if the system works still exists for each increment, the cost and time to conduct dedicated operational tests on each increment and what to test with each increment is open to discussion. For example, alternative approaches might include early operational assessments based on limited fieldings, or more simulations.

> **"In sum, DoD continues to deal with the ambiguity of applying a statutory operational test and evaluation regime enacted for a grand-design acquisition system to a new system that emphasizes evolutionary acquisition."**

This ambiguity creates conflicts, not only with the testing statutes, but also with how the operational test and evaluation community sees its role in acquisition. Then-Director of Operational Test and Evaluation Philip Coyle (2000) argued that "how evolutionary requirements are set is very important...if those requirements have not been set thoughtfully, you can have a situation where the bar has been set too high, too early, or conversely, where the bar has been set so low that user has little interest in fielding the earlier blocks" (p. 3). Coyle's advice to program managers is to "get with the testers and the users early — very early — before the sequence of requirements for each block have been locked in." At the same time, the military departments want to limit the amount of operational testing and rely more on operational assessments of each increment of capability. For example, some have argued that full operational test and evaluation should be limited to the final increment in an evolutionary program.

While the operational test and evaluation community appears to be open to rethinking the application of test given the new EA environment, there still exists a bias toward full testing of each block. For example, in recent draft language submitted for the test and evaluation section of the 5000 policy documents,[4] DOT&E argues that "all test programs must conduct developmental test and evaluation, live fire test and evaluation, and operational test and evaluation of each new block capability, and ensure adequate OT&E prior to the release of each successive block to the user."

In sum, DoD continues to deal with the ambiguity of applying a statutory operational test and evaluation regime enacted for a grand-design acquisition system to a new system that emphasizes evolutionary acquisition. In addition, the test and acquisition communities continue to work on ways to decrease the inherent conflict between a flexible development program and a disciplined test program.

CONCLUSIONS

In 1959, Charles Lindblom published an article entitled, "The Science of Muddling Through," in which he distinguished

two methods of policy formulation and implementation. The first method, the "rational-comprehensive" approach, stresses empirical analyses of numerous alternative policies in which the ends are isolated and then the means to attain them are evaluated. The test of a good policy is that "it can be shown to be the most appropriate means to the desired ends."

The second method, which Lindblom called "successive limited comparisons," closely intertwines the processes of selecting goals and conducting analyses. Analysis is not comprehensive but targeted. In this approach, the test of a good policy is "typically that various analysts find themselves agreeing on a policy (without their agreement that it is the most appropriate means to an agreed 'objective.'" The process of successive limited comparisons, or "muddling through," allows policy makers to deal with very complex organizational and process problems by blending rationality and realism.

In many ways, the science of muddling through describes the formulation and implementation of evolutionary acquisition policy in DoD. We began this article by observing that the more ambiguous a policy is, the more likely it is that the various organizations charged with implementation will emphasize their particular institutional perspectives in the policy process. And when these institutional perspectives clash, organizational conflict is inevitable, but not necessarily counterproductive.

When DoD's acquisition leaders decided in 1999 to institutionalize evolutionary acquisition in the 5000 policy documents, they were promoting a development approach that had a long intellectual history, although not much practical implementation experience outside of the software development community. They were also facing near-universal opinion — within the Department, in the defense industry, and in Congress — that defense acquisition programs cost too much and take too long to deliver. Thus there was strong consensus about a desired end state — delivering systems faster and at less cost — but not nearly as much agreement about how to achieve this vision.

> **"In many ways, the science of muddling through describes the formulation and implementation of evolutionary acquisition policy in DoD."**

In this environment, the concept of evolutionary acquisition was nonetheless an attractive alternative to the traditional "grand-design" approach. The old approach had equipped the United States with the most advanced military systems in the world but at very high costs and often only after substantial schedule delays. The new EA approach promised a way for DoD policymakers to ease the acquisition community into new ways of doing business.

There were two major compromises necessary for DoD to move from the old acquisition approach to a new one. The first compromise was one made by the leadership and that, as we have just seen, was to make EA preferred but not mandatory. While everyone did not agree that evolutionary acquisition was necessarily the best strategy for all acquisition systems, it was possible to find some consensus around the notion that EA should at least be the preferred approach. And the new 5000 policy documents

couched the institutionalization of EA in just this way — "preferred" but not required in all cases.

But all participants in the acquisition process, in effect, agreed to the second compromise. This compromise was to proceed with implementation, even though there was scant experience with implementing EA for major system developments. This is policy-making through Lindblom's successive limited comparisons — muddling through under conditions of high ambiguity. Under these conditions, the major players in the acquisition process have reacted to the new EA policy in different ways. And these reactions have forced changes and accommodations in the implementation process.

"In addition, DoD has worked out a process for implementing an evolutionary development strategy that has won the endorsement of Congress."

The first such accommodation has been to recognize that basic terms need clarification. As a result of the direction from Congress, DoD has adopted standard terminology for both evolutionary acquisition and spiral development that has been accepted by the military departments. Evolutionary acquisition is "an acquisition strategy that defines, develops, produces or acquires, and fields an initial hardware or software increment of operationally useful capability." Spiral development is "an iterative process for developing a defined set of capabilities." A related accommodation has been to recognize that well-known and long-used program strategies, such as pre-planned product improvement and block upgrades, are themselves forms of evolutionary acquisition.

Another adaptation to the new policy has been the revision of the Financial Management Regulations to realign the Research and Development budget categories. The Comptroller has recognized that the current budget categories do not appropriately align funding with evolutionary acquisition work efforts. So, Comptroller has redefined budget categories for advanced development (so-called 6.3a and 6.3b funding) to allow for work to be done without an operational requirements document, as described in the DoD Instruction 5000.2 as part of the technology development phase of evolutionary acquisition.

A third key accommodation is the use of early operational assessments — rather than full-up operational testing — to evaluate emerging increments of capability. For the Unmanned Combat Aerial Vehicle program, the Director, Operational Test and Evaluation agreed to allow operational assessments, in lieu of full-up testing, to be done on several blocks, rather than insist on conduction of independent operational test and evaluation on each block. Further, the Director has agreed that test and evaluation of an evolutionary acquisition program will be a combination of operational assessments in the technology development phase and tests in the development phase — but tests of the changes from the last increment, not full-up tests of each block.

The requirements process has also been modified. The Joint Staff is rewriting CJCS Instruction 3170 to recognize a better integration of the requirements and acquisition processes beginning with

Policy Document	EA Concept	EA Definitions	EA Diagram	EA Details Description	EA Functional Description
DoD 5000 October '00	Yes	No	No	No	No
USD(AT&L) Memo April '02	Refined	Yes	Yes	No	No
Interim Guidance October '02	Refined	Refined	Refined	Yes	No
EA Continuous Learning Module (in work)	Refined	Refined	Refined	Refined	Yes

Figure 4. Refinement of the Evolutionary Acquisition Policy

mission area analysis (a process formerly reserved exclusively for the Joint Staff and its Military Department counterparts). At every step in the process, the Joint Staff plans to work with their acquisition counterparts to allow for a better understanding of how to jointly develop time-phased requirements. Further, the Joint Staff is moving away from the use of ORDs for program initiation, recognizing that evolutionary acquisition requires more flexibility in requirements definition. So, the Joint Staff recognizes the need for a system concept document to guide the entire program and an Initial Requirements Document for each block of capability. An ORD will not be produced until a block of capability is ready for production.

In addition, DoD has worked out a process for implementing an evolutionary development strategy that has won the endorsement of Congress. Congress has explicitly endorsed the idea of flexibility prior to Milestone B and discipline after Milestone B —a hallmark of evolutionary acquisition — in the National Defense Authorization Act for Fiscal Year 2003 with language that endorses spiral development and evolutionary acquisition.

In each case, the need to reduce ambiguity and resolve institutional conflicts has pushed DoD's leadership to add richness to the process and to define how various functional disciplines (such as contracting, systems engineering, and sustainment) operate within an evolutionary acquisition strategy. Figure 4 shows a history of the refinements that have been made in the policy. Undoubtedly, the implementation process will give rise to new accommodations and course corrections as DoD continues to muddle through the new environment of evolutionary acquisition.

ENDNOTES

1. RMA is the "Revolution in Military Affairs." According to the 1999 Secretary of Defense Annual Report to the President and to Congress (page 122), an RMA "occurs when nation's military seizes an opportunity to transform its strategy, military doctrine, training, education, organization, equipment, operations, and tactics to achieve decisive military results in fundamentally new ways."

2. RBA is the "Revolution in Business Affairs." The RBA is a term coined by DoD business and management professionals, and sometimes used in official documents, to refer to the achievement of efficient business practices that create an environment for DoD to acquire goods and services better, faster, and cheaper.

3. The quote "a bridge too far" comes from a policy review meeting (held during 2000) at which the authors were present.

4. Comments submitted by Thomas Carter on draft DoD Instruction 5000.2, September 2002.

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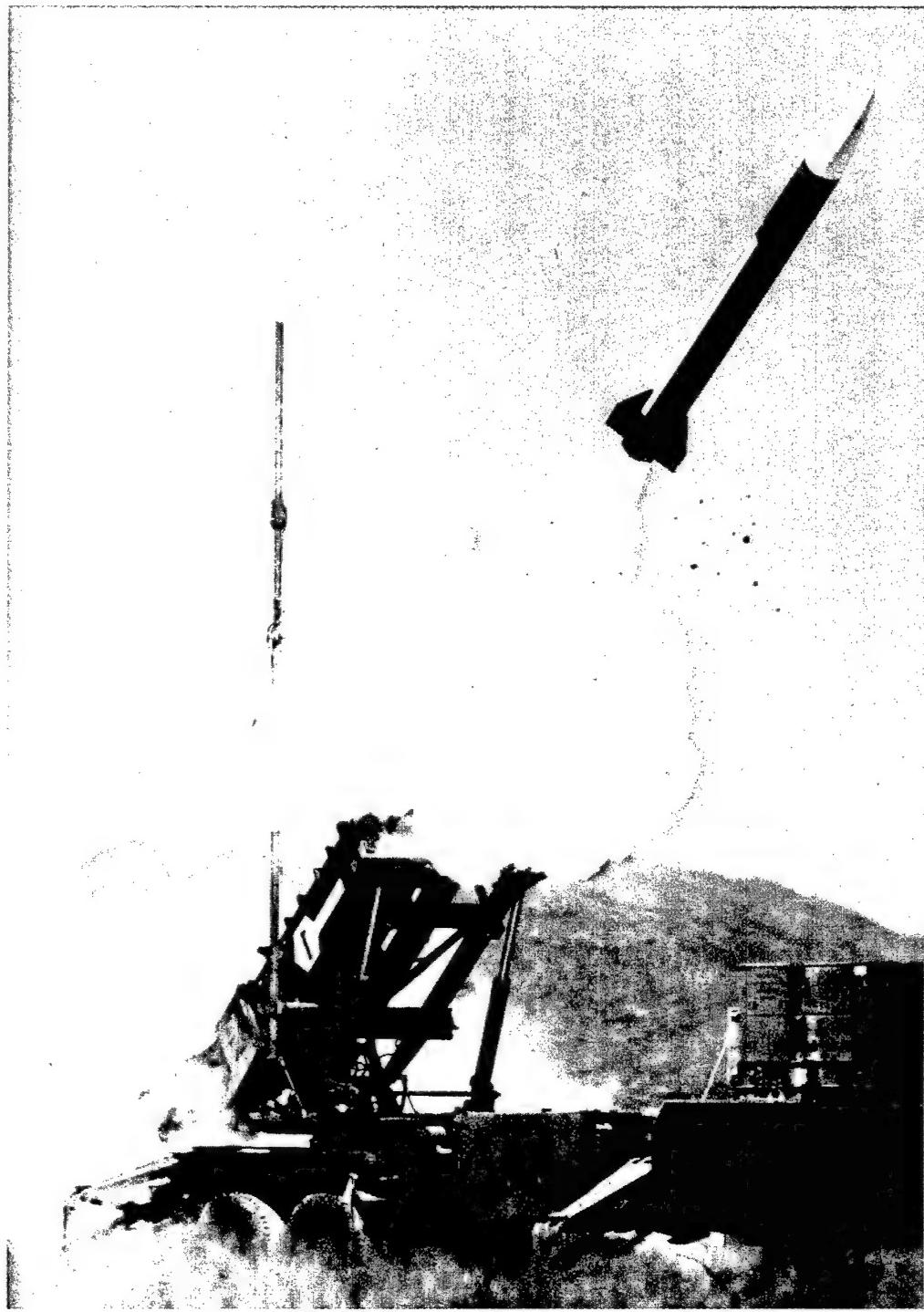
PATRIOT PAC-2 DEVELOPMENT AND DEPLOYMENT IN THE GULF WAR

J. Daniel Sherman

This case study explores the development of the Patriot PAC-2 and its historic deployment in the Gulf War from the vantage point of five senior technical managers. In addition to in-depth interviews with these senior managers, U.S. Army Aviation and Missile Command (U.S. Army Missile Command) historical documents, unclassified government reports, and other public sources were reviewed for information regarding PAC-2 development. Patriot PAC-2 is a case study in effective project management that resulted in the extraordinary acceleration in the final stages of development, production, and deployment in time to play a historic role in the Gulf War. The Patriot PAC-2 lessons may benefit future project managers engaged in the final stages of system development prior to a major conflict.

Beginning in 1966, Defense Secretary Robert McNamara authorized the contract definition for the Surface-to-Air Missile Defense (SAM-D). In 1967, Raytheon was awarded the contract for the advanced development program for SAM-D. This four-year program developed and demonstrated hardware elements and computer software that coordinated the operation of all elements performing the air defense functions from target detection

through intercept (Oldacre, personal interview, May 29, 2001). SAM-D benefited from technology transferred from the original missile designed as a defense against ballistic missile attack, Nike-Zeus. While Nike-Zeus was never actually fielded due to technological limitations, much was learned that aided the development of SAM-D.

By 1970, the Track-via-Missile (TVM) guidance seeker was demonstrated

through a series of real-time flight simulations. In mid-1970, Raytheon's contract was expanded to include an engineering development definition effort. The SAM-D engineering development program was initiated in 1972. The emphasis in this program was on the early initiation of missile flight tests. The advance development radar, computer and guidance hardware were modified to support guidance flight tests of the engineering development model missile. During the same timeframe, the engineering development model ground equipment was initiated in parallel development (Oldacre, personal interview, May 29, 2001).

During the early part of the engineering development program, critics questioned the tracking via missile concept. These discussions reached Secretary of Defense Schlesinger who concluded that the importance and the cost of the program required that the guidance system be thoroughly proved before continuing the development program. Based on these discussions, the reoriented program, called Proof-of-Principle, focused on the missile guidance system. In addition, in January 1974 Congress directed the Army to conduct a Cost and Operational Effectiveness Analysis (COEA) in coordination with the General Accounting Office (GAO).

> **"During the early part of the engineering development program, critics questioned the tracking via missile concept."**

The results of the COEA reaffirmed the need for an air defense system with SAM-D's capabilities. Initial testing conducted in 1974 verified SAM-D's on-board control system, aerodynamic and structural design of the missile, and in-flight acquisition and tracking by the ground based fire control group. In early 1975, in a test at White Sands Missile Range, SAM-D successfully destroyed a drone in its first engineering development test of the TVM guidance system. Subsequent tests proved that the TVM guidance system was robust against a variety of maneuvering targets and countermeasures. As a result of the performance in the Proof-of-Principle program, SAM-D was approved for return to full-scale development in January 1976 (Capps, personal interview, April 26, 2001).

In 1976, with the resuming of full-scale development, SAM-D was renamed Patriot. By 1977, an Army System Acquisition Review Council (ASARC) decision was made to accelerate the program. This decision moved the production date up from the original schedule of March 1983 to April 1980. This entailed the risk that the initial production equipment would not have the required operational reliability and software maturity. This decision resulted in the elimination of the third phase development tests and operational tests (DT/OT III). These tests were replaced with a production confirmatory test and a follow-on evaluation (Fenstermacher, 1990).

In September 1980, following the Defense Systems Acquisition Review Council III (DSARC III) production readiness review, low rate production for Patriot was approved subject to a verification test program. In October 1980, Raytheon began the initial low rate production that included five fire units and 155 missiles. This initial production was accompanied by a series of Follow On Evaluation (FOE) tests that included operational software tests, testing of diagnostic software, retrofitting and testing of the missile, and checking reliability, availability, and

maintainability (RAM). The final set of tests would be completed with the production equipment and with operational personnel. This test would be known as FOE-II.

The first production units came off the line in early 1983. The operational tests began in June 1983 at White Sands Missile Range under the supervision of the Army Operational Test and Evaluation Agency (OTEA; Annual Historical Review, 1984). FOE-II would be the first time combat troops would actually use Patriot in an operational environment. The tests would include search and track scenarios, simulated and live missile firings, including day and night operations. (Fenstermacher, 1990).

FOE-II did not go well and the test results were substandard. There was excessive equipment downtime. Diagnostic and corrective action was complicated and led to delays in returning the equipment to an operational status. It became immediately clear that much of the equipment failure was due to production quality control deficiencies. As the tests continued problems multiplied, disagreements emerged regarding the design of the operational tests, and an adversarial relationship began to develop between Raytheon and OTEA. Before FOE-II was completed, OTEA made the decision to discontinue the operational testing. This turn of events was a shock to both Raytheon and the Patriot project office.

Following the discontinuation of FOE-II, Patriot was placed on what was labeled a "milestone schedule." The previous schedule for deployment to Europe was cancelled and Raytheon was instructed to systematically correct each problem that had been identified during the FOE-II

tests. The milestone schedule meant that deployment and full-rate production were postponed indefinitely. Only after a new Follow On Evaluation (FOE-III) would full-rate production begin.

LESSON 1: A CORPORATE CULTURE THAT RESPONDS TO ADVERSITY

Raytheon had been prepared to launch full-rate production. With the failure of FOE-II, production capacity and staffing would not be utilized. Patriot was Raytheon's largest single program, and in 1983 it represented approximately 20 percent of the company's total sales revenue. Both Raytheon corporate management and the engineers in the Missile Systems Division knew that Patriot would either be deployed or cancelled based on the success of the impending FOE-III testing (Fenstermacher, 1990).

"It became immediately clear that much of the equipment failure was due to production quality control deficiencies."

What transpired next can only be described as a massive corporate response to the challenge that entailed extraordinary effort on the part of Raytheon's Missile Systems Division. Engineers scrutinized every aspect of the FOE-II test results in an effort to identify every potential problem source and take corrective action. A concerted effort was mounted to improve software diagnostics. Sensors were added to the system so that operators could detect faults more readily. The technical manuals were rewritten based on the Patriot project office guidance on specific procedures (Annual Historical

Review, 1984). Raytheon corporate management brought in William Swanson, a very talented production manager, to turn around the Andover, Massachusetts production facility. Swanson overhauled the entire quality control system and vastly improved production quality.

Steve Stanvick, the Patriot chief engineer at Raytheon, was placed in charge of the FOE-III preparation. Stanvick realized that the existing organization within the Missile Systems Division resulted in diffused responsibility. To correct this problem, he created a temporary organizational structure in which engineers were grouped into ad hoc teams with a single technical manager over each major area. John Kelley, the manager of flight tests, observed that many of the technical professionals were routinely working 60-hour weeks during this period. Levels of exhaustion were high, but the relentless effort to correct each problem in preparation for FOE-III continued on its compressed schedule (Kenger, personal interview, June 28, 2001).

> **"The corrective action system that was instituted resulted in impressive improvements in a period of less than one year."**

In July 1984 FOE-III was initiated. The tests were extraordinarily successful. Patriot surpassed all the acceptable target values, and in some cases by margins in excess of 50 percent. During the tests the system was operational over 90 percent of the time. The missile flight tests achieved a 100 percent rating by OTEA and the testing was completed ahead of schedule in September 1984 (Annual Historical Review, 1985). Immediately following the successful FOE-III tests, the decision was made to ramp up production and begin the deployment of Patriot in Europe.

The corrective action system that was instituted resulted in impressive improvements in a period of less than one year. This structured response to the FOE-II crisis literally reshaped the company's approach to the transition from development to production for the future (Capps, personal interview, April 26, 2001). This would turn out to be important as the program moved into PAC-1, and historically significant, during the accelerated transition to production for the PAC-2 Gulf War deployment. It is to Raytheon's credit that the firm possessed the corporate culture that embraced such a radical turnaround.

The lesson that may be learned from this is that those companies that are able to develop a corporate culture that can respond to adversity will be able to succeed when faced with enormous challenges. However, those that are unable to develop corporate cultures with this characteristic will tend to fail. There may also be an ancillary lesson. The government OTEA and program managers were very astute in creating a situation between FOE-II and FOE-III where the large incentive of the production contract was placed in jeopardy. When faced with potentially large financial consequences, most firms will respond accordingly.

LESSON 2: THE TACTICAL MISSILE THREAT AND OBTAINING SUPPORT FOR PAC-1 AND PAC-2

The original requirements for Patriot (SAM-D) included an anti-tactical ballistic missile capability. However, the Training

and Doctrine Command (TRADOC; the Air Defense Command) eliminated this requirement early in the program. The program prior to the start of full-rate production in 1984 focused exclusively on the anti-aircraft requirement. The issue of the added anti-tactical missile (ATM) capability had encountered some resistance from the beginning within TRADOC. The reasons were varied, but included the issues of cost, schedule, and technical difficulty. In this regard, in order to achieve the anti-aircraft capability, the technical development effort was so significant that the consensus between TRADOC and the Patriot project office was to focus resources on this critical task. To attempt to achieve both objectives from the beginning would diffuse resources and inevitably prolong the development schedule (Capps, personal interview, April 26, 2001).

A second counter-argument that was generally accepted by TRADOC was that tactical missiles were inherently inaccurate, and therefore, posed a lesser threat to military targets (Capps, personal interview, April 26, 2001). As events unfolded in 1990 and 1991, however, the fallacy in this argument would become extremely clear because of their potential as a weapon of terror against civilian populations.

In any case, by 1985 Patriot was progressing in high rate production, and Colonel Lawrence Capps replaced Brigadier General Donald Infante as project manager of the Patriot project office. With production under way, the timing was right to shift attention to the tactical missile threat. The specific threat was the Soviet SS-21, and this became Colonel Capps primary objective. Achieving the

anti-tactical missile capability would require resources, and TRADOC (the Air Defense Command) was ambivalent. However, Colonel Capps persisted in successfully convincing the Office of the Secretary of Defense (OSD) to allocate budgetary resources to the program (i.e., OSD directed funds). During this same timeframe the Patriot project office succeeded in negotiating a multiyear production contract (five year contract) with Raytheon (Capps, personal interview, April 26, 2001). This was an important development because it provided the level of funding stability that would be required to keep the anti-tactical missile program on track.

Initial efforts were called Patriot Anti-tactical Missile Capability-1 (PAC-1), which involved software changes to reshape the radar search pattern and to reshape the missile trajectory (Annual Historical Review, 1986). The test results were promising, but it was clear that changes were needed to the warhead and fuze to make the system more effective. However, it was apparent that these measures would still not be sufficient to gain the increase in the guidance accuracy needed. Thus, in order to increase both political and budgetary support, the Germans were approached regarding a joint program. The Germans communicated a high level of interest. They were already acquiring Patriot missiles and the anti-tactical missile capability was attractive to them.

In 1986, the Germans agreed to fund 40 percent of a program for an experimental

> **"Achieving the anti-tactical missile capability would require resources, and TRADOC (the Air Defense Command) was ambivalent."**

new seeker called the multi-mode seeker. This 60/40 split was sufficient to fund a phased effort that was to test the seeker in hardware-in-loop ground simulation tests, and then incorporate it into the missile and conduct flight tests (Capps, personal interview, April 26, 2001). However, this new missile seeker was destined never to reach production, as events would drive the schedule into rapid production of the existing PAC-2 design.

These events suggest an important lesson. Exceptional project managers, like Lawrence Capps, will have the foresight to understand the evolving threat. Exceptional project managers will also succeed where others may fail in obtaining the necessary resources to accomplish the task in the face of resistance and competition for scarce resources. In the case of Patriot, Lawrence Capps not only succeeded in obtaining OSD directed funds, but by thinking outside the box, he was able to help assemble the joint venture with the Germans. This resulted in the acquisition of the additional resources necessary to support the anti-tactical missile development.

> **"Exceptional project managers will also succeed where others may fail in obtaining the necessary resources to accomplish the task in the face of resistance and competition for scarce resources."**

PAC-1 AND PAC-2 PROGRAMS PROCEED ON SCHEDULE AND WITHIN BUDGET

The first phase of the advanced capability program, PAC-1, involved software modifications to the Patriot ground equipment and improved guidance and control.

These software changes would allow the Patriot missile to essentially fly up the reverse trajectory of an incoming SS-21 missile. The PAC-1 software changes allowed the radar to orient into a high altitude search mode for surveillance tracking and launch against the inbound missile.

In April 1985, Raytheon completed the system definition effort for the PAC-1 ATM software modifications. The PAC-1 software development contract was awarded to Raytheon in June 1985. By July 1986 the software changes had been completed and validated. In a test at White Sands Missile Range in September 1986, a Patriot missile successfully intercepted a Lance missile similar to the Soviet SS-21. Following the testing, the PAC-1 capability was deployed with the release of the Post Deployment Software Build #2 in July 1988 (Annual Historical Review, 1989).

The second phase of the advanced capability program, PAC-2, involved missile modifications including the fuze, warhead, software modifications, and new guidance algorithms. The PAC-2 program provided Patriot with catastrophic kill capability against longer range, Intermediate-range Nuclear Forces (INF) treaty compliant missiles such as the Soviet SS-23. The modifications to the warhead included larger hardened steel fragments that would be released following detonation of almost 100 pounds of high explosive. This improvement was necessary in order to penetrate the shell surrounding the Tactical Ballistic Missile's (TBM's) warhead. The fuze, developed by the Harry Diamond Labs and Bendix Corporation, had a faster reaction time that was necessary for high closing-speed

engagements (Moore, personal interview, April 27, 2001).

The Patriot system consisted of a ground radar, an engagement control station, an antenna, an electric power plant, and typically eight launchers per fire unit. Each launcher contained four missiles in its individual storage, transportation, and launch containers. The radar was a multifunctional phased arrayed radar that performed a variety of surveillance, acquisition, and guidance tasks in directing a battery of launchers. With multiple guidance modes, the system had the capability to switch modes to adjust to enemy electronic counter measures. The missile was 17.4 feet in length and was powered by a solid propellant rocket motor that approached mach 3 speeds. The missile itself weighed 2200 pounds and had a range of 43 miles (Annual Historical Review, 1990).

PAC-2 development proceeded through 1986, 1987, and 1988. In addition to the work on the fuze and the warhead, software development proceeded on incorporating the pulse doppler search/ track capability. Additional preplanned product improvements during this timeframe included the clutter canceller modification, integration of the modular azimuth and positioning system with Patriot, the standoff-jammer counter, and improvements to reliability, availability, and maintainability (Annual Historical Review, 1989).

The testing program included component level, subsystem level, and system level testing. Extensive software testing included stand alone tests and hardware in the loop tests. The warhead testing verified its spray pattern, fragment velocity, and fragment ruggedness. The fuze

underwent testing to verify its performance on a variety of targets with different trajectory geometries and closing velocities. With the success of the test program, by December 1988, the Army In-Process Review (IPR) approved production for PAC-2 (Moore, personal interview, April 27, 2001; Kenger, personal interview, June 28, 2001).

The PAC-2 production run began in February 1989. Raytheon in Andover, Massachusetts built the guidance section. Morton Thiokol at Redstone Arsenal produced the propulsion section. Martin Marietta in Orlando completed the final assembly. Given the long lead-time on production, the first PAC-2 missiles were scheduled to be fielded in early 1991 (Annual Historical Review, 1990).

LESSON 3: PAC-2 SCHEDULE AND COST PERFORMANCE CAN BE ATTRIBUTED TO SOUND ACQUISITION STRATEGY, TECHNOLOGICAL READINESS, AND EFFECTIVE PROJECT MANAGEMENT

One important factor that contributed to the PAC-2 schedule and cost performance was a sound acquisition strategy. Following initial development, the first Patriot production contract was awarded on a cost plus incentive fee/award fee basis. This type of contract was selected by design in order to distribute risk at a level acceptable to both the contractor and the government. As the Patriot system matured, and cost and technological uncertainty decreased, cost type contracts began to be partially replaced by fixed price incentive and, in some instances, firm fixed price contracts. On a proportional

basis, this placed increased monetary risk on Raytheon and the subcontractors relative to the government (Capps, personal interview, April 26, 2001). However, with risk being reduced as a result of technological readiness and production knowledge, this was acceptable to Raytheon and the subcontractors.

In March 1987, a multiyear production contract was awarded to Raytheon. This five-year contract allowed Raytheon and the subcontractors to lower costs through economies of scale in lot purchasing, efficient utilization of facilities, and reduction in contract administration costs. While PAC-2 did not transition into production until 1989, the primary effect of this multiyear contract on PAC-2 was the overall funding stability that it provided. Retired Brigadier General Capps (personal interview, April 26, 2001) observed that this funding stability for the Patriot program was important in keeping PAC-2 development on schedule. The PAC-2 program could be injected into the ongoing production program by cutting in engineering change proposals rather than starting an entirely new production line. This approach resulted in maximum efficiency.

While incentive fees were commonly utilized with the development contracts, the most critical incentive was the continuation of the large production contracts. Therefore, by creating incremental project milestones for design and testing during engineering development, the financially lucrative production contract could be

"While incentive fees were commonly utilized with the development contracts, the most critical incentive was the continuation of the large production contracts."

obtained by successfully achieving each of the sequential milestones.

The technological readiness level, or maturity, was also a factor that contributed to PAC-2 schedule and cost performance. A.Q. Oldacre (personal interview, May 29, 2001), the deputy project manager for the Patriot project office during PAC-2, observed that because work on Patriot had been progressing at Raytheon since 1967, Raytheon had built a large base of pertinent technical knowledge. In the Raytheon laboratories, knowledge of the basic technologies such as phased array radar, guidance and control, and software had reached a high level by the time of the inception of PAC-1 and PAC-2.

Similarly, in the Army laboratories a large base of technical knowledge had developed over the same timeframe. For example, in the Research, Development, and Engineering Center (RDEC) at Army Missile Command (MICOM), the Software Engineering Directorate managed the Patriot software verification and validation program in cooperation with the Patriot project office. The RDEC Guidance and Control Directorate assisted with hardware validation and developed simulations for Patriot jointly with Raytheon. The PAC-2 fuze was developed with Harry Diamond Labs, and RDEC at MICOM assisted in fuze testing. In addition, Aberdeen conducted the PAC-2 warhead testing. This extensive base of expertise in the government laboratories and test facilities contributed to the high technological readiness level that facilitated PAC-2 development schedule performance (Oldacre, personal interview, May 29, 2001).

Effective project management also contributed significantly to the PAC-2 schedule and cost performance. The government

project office utilized a functional structure with a program management office that included an acquisition management branch, a cost estimating/budget branch, and a cost/schedule control branch. There was a production/configuration management office, a hardware engineering division, a software engineering division, a product assurance division, and a systems engineering division. In addition, there was an office for Patriot support that included deployment management, logistics management, and a Patriot readiness center. The project office also included a project counsel legal office, an administrative office, and liaison offices for Germany, Japan, and the Netherlands (Moore, personal interview, April 27, 2001).

At Raytheon, the Patriot program office within the Missile Systems Division included personnel who would interface with the government counterpart in the various functional areas. The program office contained a large technical staff. Raytheon utilized a laboratory structure where engineers in the Bedford system design lab, systems engineering lab, software engineering lab, test lab, and so forth, were in a matrix organization with the program office functional areas.

This system worked effectively for several reasons. First, during the PAC-2 timeframe Raytheon retained a large technical staff in the program office itself. These individuals, for the most part, had extensive Patriot experience in their respective areas of specialization. Secondly, there was significant technical depth in the Bedford labs in each area that pertained to the Patriot system. Third, the coordination within this matrix system in terms of task assignments was managed

effectively. Finally, the interface between the Raytheon program office, the subcontractors, and the government Patriot project office was effectively managed (Kenger, personal interview, June 28, 2001; Sanborn, personal interview, June 28, 2001).

PAC-2 development occurred in an era before integrated product teams began to be used widely. However, temporary or informal modes of cross organizational integration were implemented that had some similar characteristics to integrated product teams. Larry Moore (personal interview, April 27, 2001), Patriot project office technical director, observed this occurring in the software engineering area with the creation of teams that included Raytheon personnel, project office personnel, and the contractor or Software Engineering Directorate personnel involved in validation. However, Moore also observed that structural modes of integration (like cross functional or cross organizational teams) are only effective to the degree that the individuals involved have the requisite level of technical knowledge and to the degree that those individuals are striving to work cooperatively. In the absence of cooperation and requisite technical expertise, structural modes of coordination are ineffective. A.Q. Oldacre (personal interview, May 29, 2001), the deputy project manager during PAC-2, noted that the level of cooperation and the openness regarding disclosure of problems was such that coordination

> **"In the absence of cooperation and requisite technical expertise, structural modes of coordination are ineffective."**

between Raytheon and the project office was extremely effective.

When PAC-2 entered production, the effectiveness of this coordination was facilitated by the fact that the Patriot project office had a team of engineers on site at the Raytheon Andover manufacturing facility as liaisons. Furthermore, internal coordination at Raytheon had improved significantly over the initial production runs. To facilitate the transition to production, engineers that were involved in Research and Development (R&D) design work served in an advisory capacity during the transition to production. Similarly, production engineers at Raytheon provided input into design decisions at earlier stages in order to insure design for manufacturability (Oldacre, personal interview, May 29, 2001).

"On August 2, 1990, Saddam Hussein launched the Iraqi invasion of Kuwait."

This was a clear case of organizational learning. In the initial production runs, this type of integration, which is characteristic of concurrent engineering, was not in place. By 1989, when the PAC-2 changes and the other preplanned product improvement changes were moving into production, integration had been improved significantly. These factors demonstrate the high production readiness level at Raytheon that also contributed to schedule and cost performance.

LESSON 4: IN WAR, ONE MUST LEARN TO EXPECT THE UNEXPECTED

On August 2, 1990, Saddam Hussein launched the Iraqi invasion of Kuwait. At this point, the PAC-2 missiles were in the production build-up cycle with the first missiles scheduled to come off the production line in approximately five months. Only three PAC-2 R&D missiles were in the inventory in August 1990, and these had been scheduled for use in operational testing. While the development testing had been completed, there was still operational testing that remained to be conducted (Annual Historical Review, 1991).

The intelligence reports coming back from the Middle East immediately communicated the nature and the extent of the Iraqi missile threat. The missile was the Soviet-built Scud. However, PAC-2 had been designed to counter the SS-21 and SS-23 threats. The Scud had been discounted because it was an older system that the Soviets had replaced with their more modern systems. The Soviets had sold their aging fleet of Scud missiles to their third-world allies, and Iraq was preparing to use this weapon against the U.S. forces and our Coalition allies. To make matters worse, the Iraqi Scuds had the capability of delivering both conventional and chemical warheads. Furthermore, the Iraqis had modified the propulsion section so that the Scuds range was capable of reaching the population centers of Israel.

As if the situation could not be any worse, the Iraqi propulsion modifications also resulted in higher velocities than the SS-21 or SS-23. Hence, the modified Scud Al-Hussein reached velocities of 6,500 to 7,200 feet per second. The Soviet missiles the PAC-2 had been designed to intercept reached velocities between 5,200 and 5,900 feet per second. As Herb Sanborn (personal interview, June 28, 2001), Raytheon Patriot systems engineering manager, observed, "in war, one must learn to expect the unexpected."

In the first week of August 1990, what was unfolding was nothing less than an engineering and production challenge of historic proportions. Not since 1944 had an American defense firm and a government project office been faced with a challenge of this magnitude. Colonel Bruce Garnett, the Patriot Project Manager, was summoned to Washington where he was asked to present the simulation data that had been developed by RDEC at MICOM and Raytheon. Upon reviewing the information, the Army Chief of Staff, and subsequently General Colin Powell, made the decision to deploy PAC-2 in the Persian Gulf (Oldacre, personal interview, May 29, 2001). The Program Executive Officer, Brigadier General Robert Drolet, directed an emergency early release of Post Deployment Build-3 (PDB-3) with necessary software modifications, and parallel final tests to assure that adaptations for the Iraqi Scud worked properly (Annual Historical Review, 1992).

What transpired next could only be described as an extraordinary acceleration of effort. A.Q. Oldacre, the deputy project manager, without any formal contract, on a phone call alone, instructed the Raytheon program office to accelerate production as rapidly as possible. Raytheon immediately moved into 24 hour, 7 days per week, full-plant capacity production. The actual production contract followed weeks later and formalized the agreement. This unusual event illustrated the level of trust that existed between the prime contractor and the project office. It also illustrated that, when faced with the imminence of war, both Raytheon and the Patriot project office were prepared to do whatever was necessary in the national interest (Oldacre, personal interview, May 29, 2001).

With production under way, concurrently, Larry Moore and Don Adams at the Patriot project office in Huntsville, in cooperation with Raytheon, initiated the effort to make the necessary software modifications to counter the Scud threat. The software engineers at Raytheon immediately realized what the challenge entailed and moved into a mode of extraordinary effort. In order to make the necessary software modifications and conduct the validation testing, it was reported that software engineers at Raytheon were working 16-hour days. For Walt Trainor at Raytheon, and A.Q. Oldacre at the Patriot project office, this effort would be their greatest challenge (Moore, personal interview, April 27, 2001; Oldacre, personal interview, May 29, 2001).

While this was occurring, the German PAC-2 production line also transitioned to full capacity. In coordinating production, it soon became apparent the production of the new warheads in the United States was roughly two months behind the German contractor, MBB, as a result of a labor strike. Consequently, the Patriot project office coordinated a transfer of German-built warhead parts to the United States for assembly. As a result, daily deliveries of parts were shipped from the MBB plant in Bavaria to Ramstein, then on to Dover Air Force Base in Delaware, then to East Camden, Arkansas for warhead subassembly, and finally, to Orlando for final missile assembly (Moore, personal interview, April 27, 2001).

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By January 1991, 424 PAC-2 missiles had been shipped to the Persian Gulf (Davis, 1992). However, it was unclear if this would be sufficient as intelligence data revealed the magnitude of the Iraqi Scud threat. By this time warhead production in Arkansas, guidance section production at Raytheon in Massachusetts, and fuze production in Baltimore were exceeding the final assembly capacity of Martin-Marietta in Orlando.

As a consequence, the Patriot project office shifted its focus to converting PAC-1 missiles in the inventory into PAC-2's. This assembly process involved changing the warhead, fuze, software, and other changes to a number of the existing missiles in the inventory. The missile forebody was sent to Raytheon for the replacement of components, then a second final assembly facility was brought on line at Red River Army Depot, and a third was brought on line in Germany. Running parallel assembly operations resulted in a significant increase in the number of missiles being shipped to the Persian Gulf as hostilities erupted in January 1991 (Oldacre, personal interview, May 29, 2001).

"In large complex projects, learning curves should not be underestimated."

Several important factors contributed to the ability of Raytheon and the Patriot project office to exhibit such extraordinary organizational agility in adjusting rapidly to the changed requirements and the need to accelerate PAC-2 production. A.Q. Oldacre (personal interview, May 29, 2001) and Larry Moore (personal interview, April 27, 2001) from the Patriot project office, and Herb Sanborn (personal interview, June 28, 2001) from

Raytheon considered stability and continuity in staffing to be an important contributing factor. This was important particularly in the effort to rapidly modify and test the software to allow for the interception of Scud missiles. Many of the key technical people at both Raytheon and the government project office had worked on the program for over 10 years. This depth of experience that was system-specific proved to be critical when the rapid changes were required.

In large complex projects, learning curves should not be underestimated. While there is an advantage to some degree of movement of technical personnel to transfer knowledge and ideas from other projects, this can reach a suboptimal level. What is needed is a core of highly talented individuals with extensive system specific or domain specific knowledge. This was critical, particularly in areas like software, and this contributed significantly to the ability to adjust so rapidly.

The dramatic acceleration of production was made possible by several important factors. First, the Army had the foresight to contract with Raytheon (and the subcontractors) to develop the tooling and production facilities so that the capacity would be in place in the event of war. A second contributing factor was the level of training and expertise of Raytheon production personnel. This had the effect of ensuring quality as production ramped up to 24-hour, 7-day schedules at full-plant capacity. Another factor that affected quality was the numerous quality control initiatives implemented by the production manager, Bill Swanson, during the period between FOE-II and FOE-III (Fenstermacher, 1990). The changes that were

implemented during that timeframe paid very real dividends as production accelerated in preparation for war.

Finally, the Patriot project office had the foresight to insure multiple production sources of critical components. Thus, when Chamberlain was seriously behind schedule on warhead production, the adjustment could be made to procure the warheads from MBB in Germany. Similarly, parallel production could be brought on line when the effort shifted to transforming a number of existing missiles to PAC-2 missiles.

Brigadier General Larry Capps (personal interview, April 26, 2001) observed one other factor that allowed for the extraordinary acceleration in production — the restricted level of breakout. During the mid-1980s there had been an effort on the part of the Department of the Army to increase the level of breakout, or the level and number of subcontractor production contracts, on numerous programs. The logic of this strategy was to reduce costs through increased competition. In the case of Patriot, the project office carefully managed this effort, and breakout was actually relatively restricted as a result. This proved to be providential because when Patriot production had to be accelerated to meet the requirements of the Gulf War, a larger network of suppliers would have inevitably slowed production due to the complexities and inevitable uncertainties of coordination.

Another important factor that contributed to the ability to rapidly shift the systems' guidance from aircraft, SS-21 and SS-23 missiles to Scud missiles, was the fact that Patriot was designed to be extremely robust. As Herb Sanborn (2001) observed, in order to be prepared for

unexpected eventualities, a missile with multiple guidance modes (to avoid electronic countermeasures), and the capability to modify guidance algorithms as well as other ground software in a short period of time, allows for greater versatility.

There was one more factor that contributed to the dramatic acceleration in production and the rapid implementation of software changes. This can perhaps be described as a cultural characteristic that Americans seem to possess. It is an extraordinary ability to rise to challenges and exhibit extreme levels of motivation in the face of a national crisis. A. Q. Oldacre (personal interview, May 29, 2001) described it in this way: "I have often wondered whether or not this country could still do things like it did in World War II. I know now that it can. If we turn it on, and ask our industry and our people to do things like we did in World War II, there is no doubt in my mind that we could do it again."

> **"...a cultural characteristic that Americans seem to possess...is an extraordinary ability to rise to challenges and exhibit extreme levels of motivation in the face of a national crisis."**

PAC-2 PLAYS A CRITICAL ROLE IN THE GULF WAR

The United States and Coalition forces launched the massive air attack on Iraq on January 17, 1991. On January 18, Iraq initiated use of its weapon of terror by launching Scud missile attacks on military targets and civilian populations. Due to the tremendous production acceleration that had been occurring since August,

there were over 400 Patriot PAC-2 missiles in the Persian Gulf by this date. Patriot units immediately went into action to counter the threat. This would be the first time in history that tactical ballistic missiles would be used in hostile wartime attacks on civilian populations. This would also be the first time in history that these attacks would be countered with an anti-tactical ballistic missile.

"While incentive fees were commonly utilized with the development contracts, the most critical incentive was the continuation of the large production contracts."

As the war progressed, software adjustments were made to respond to observations from combat (Blair, Obenski, & Bridickas, 1992). Because the Scud missile tended to breakup during the final phase of its trajectory (re-entry into the atmosphere), multiple targets would appear on the radar screen. Engagement operations were modified to reduce undesirable engagements. Raytheon and Patriot project office personnel worked rapidly to make further adjustments to reduce tracking and engagement of false targets (targets that were not incoming warheads).

Other forms of radar interference (i.e., backload reflection) were discovered and rapidly corrected by Raytheon engineers in Saudi Arabia and Massachusetts as the Scud attacks proceeded (Moore, personal interview, April 27, 2001). By February 28, 1991, estimates of successful interception ranged as high as 70 percent in Saudi Arabia and 40 percent in Israel (Oldacre, personal interview, May 29, 2001).

There was some controversy over the question of exactly how many of the 159 Patriot missiles launched during the conflict actually intercepted their targets (Davis, 1992). Part of the controversy can be attributed to reporting deficiencies. Performance assessments were also subject to differing definitions. For example, if a Scud missile was approaching an airbase, and the Patriot did not destroy the warhead but did divert its path so that the warhead landed in the desert, some defined this as a successful intercept. Others defined this as a failed intercept.

Another issue was the difference between the performance in Saudi Arabia and Israel. In large part, this could be explained by the differences in training levels between U.S. and Israeli units, differences in engagement control, and the fact that it was used to defend large geographic urban areas in Israel versus small geographic area military bases in Saudi Arabia (Oldacre, personal interview, May 29, 2001).

Regardless of any controversy regarding the number of Scuds that were destroyed, disabled or diverted, the fact remains; Patriot saved many lives, both civilian and military. For an incremental development investment under $150 million, the PAC-1 and PAC-2 programs enabled the Patriot air defense system to be upgraded from anti-aircraft to anti-tactical ballistic missile capability. This achievement made the Patriot PAC-2 one of the most cost effective defense systems in the U.S. inventory.

Perhaps the most important contribution made by PAC-2 in the Gulf War

was its critical role in holding the fragile multinational Coalition together. The historical significance of this role has been underestimated. Patriot was the only defense against the Scud attacks on Israel. When Saddam Hussein began launching Scud missiles at the major population centers in Israel, the pressures mounted for Israel to be drawn into the conflict. Had this occurred, the likelihood of the Coalition unraveling would have been extremely high. With such a chain of events, and in light of the chemical, biological, and nuclear capabilities in the region, one can only speculate as to where the escalation would have ended.

Note: Patriot PAC-2 continued to be fielded throughout the 1990s. Following the Gulf War, engineering development was initiated on Patriot PAC-3. PAC-3 would include an improved interceptor, enhanced radar and communications equipment, and updated software. Operational test and evaluation occurred in 2002 (Patriot Advanced Capability-3, 2002).
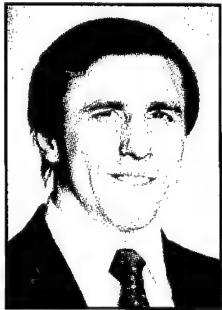
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ACRONYMS

AMCOM – US Army Aviation and Missile Command

ASARC – Army System Acquisition Review Council

COEA – Cost and Operational Effectiveness Analysis

DSARC III – Defense Systems Acquisition Review Council III

DT/OT III – Development Tests and Operational Tests

FOE – Follow On Evaluation

GAO – General Accounting Office

INF – Intermediate-range Nuclear Forces

IPR – In-Process Review

MBB – German defense firm

MICOM – U.S. Army Missile Command

OSD – Office of the Secretary of Defense

OTEA – Operational Test and Evaluation Agency

PAC-2 – Patriot Advanced Capability-2

PDB-3 – Post Deployment Build-3

RAM – Reliability, availability, and maintainability

RDEC – Research, Development, and Engineering Center

SAM-D – Surface to Air Missile Defense

TBM – Tactical Ballistic Missile

TRADOC – Training and Doctrine Command

TVM – Track-via-Missile

THE CIA'S IN-Q-TEL MODEL
ITS APPLICABILITY

Wendy Molzahn

In July 1999, the Central Intelligence Agency (CIA) chartered and funded a newly established corporation, In-Q-Tel, Inc., to search the private sector for promising commercial technologies and to invest in the development of new technologies to support the Agency's critical intelligence missions. Overviews are provided of the structure, processes, and problems associated with the In-Q-Tel model; the Department of Defense's (DoD) current ability, through innovative programs and flexible contracting authorities, to attract cutting-edge technologies; and the potential costs and benefits of establishing a "venture catalyst" firm similar to In-Q-Tel for DoD. Finally, it is recommended that DoD establish a "venture catalyst" firm as a tool to attract new technologies in addition to — rather than as a replacement for — existing programs and authorities. Success will depend on DoD's ability to transform its culture to accommodate innovation, risk, and flexibility.

The military's new dependence on information systems was driven home Thursday by Defense Secretary Donald H. Rumsfeld in a speech aimed at refocusing the Pentagon's efforts to change the military to better counter the threats of the 21st century. In robust defense of President Bush's proposed $48 billion increase in military spending next year, Rumsfeld called for more funding for intelligence and more attention to unpiloted aircraft and other sophisticated reconnaissance systems. "We need to find new ways to deter new adversaries," Rumsfeld said. "We need to make the leap into the information age, which is the critical foundation of our transformation efforts."

"War Success Propels Shift to Digits,"
The Washington Post, February 2, 2002

n 1998, senior officials in the Central Intelligence Agency (CIA) began to realize that there was a significant information technology (IT) gap between the Agency, which continued to leverage off of past accomplishments, and the private sector, which was transforming its enterprises through the use of cutting-edge technologies. The CIA leadership determined that in order to regain the lead in technology the Agency experienced in the 1950s and 1960s during the development of the U-2, SR-71, and CORONA reconnaissance programs, it would need to establish a vehicle to tap into private sector advances in information technology (Yannuzzi, 2000). In May 1998, George Tenet, the Director of Central Intelligence (DCI), announced in his "Strategic Direction" initiative:

> Beginning with the critical field of IT, we will pursue this [new] approach through the creation of an external nonprofit enterprise designed to be electronically connected to leading research throughout the country. This new entity will speed insertion of mature technologies, support rapid development of mission-critical applications, and enhance our ability to attract the skills and expertise vital to our success. (Business Executives for National Security [BENS], 2001, p. 5)[1]

A working group of senior CIA officials was chartered to develop and execute the DCI's concept. With the assistance of a consulting firm and a law firm, the working group analyzed several federal government models before deciding on a hybrid model that incorporated aspects of private sector venture capital firms and government technology procurement models. The purely government models were rejected for several reasons — the most significant reason being that the working group was not convinced that a government organization could react with lightning speed to changes in the dynamic commercial IT environment (BENS, 2001).

At the request of the CIA, Norman Augustine, former CEO of Lockheed-Martin, founded In-Q-Tel (originally named Peleus, Inc. and then In-Q-It) as a private sector corporation in February 1999. It remains a nonprofit, non-stock corporation, incorporated in the state of Delaware and exempt from federal income taxation under section 501(c)(3) of the Internal Revenue Code. In-Q-Tel's Certificate of Incorporation dated 16 February 1999, states that its purpose is to:

- Perform and promote research and related scientific endeavors in the field of IT;

- Foster collaborative arrangements that make private sector IT expertise more readily accessible to agencies of the United States; and

- Foster the development of IT that will benefit the public, private, and academic sectors of the United States (BENS, 2001).

In-Q-Tel was designed to be flexible enough to allow for interface with all elements of the IT community, the technology industry, and academia. Its mission, as originally stated, was "to exploit and

develop new and emerging information technologies and pursue R&D that produce innovative solutions to the most difficult problems facing the CIA and the Intelligence Community" (BENS, 2001, p. 6).[2] The organization's vision, according to its July 1999 Charter Agreement is to…[I]nvent the Agency of the future by raising its IT competence to that of the best practices of the private sector and then to explore new areas of research that equip it with capabilities that protect and advance our country's national security well into the 21st century. (BENS, 2001, p. 6)[3]

The In-Q-Tel CEO and Board of Trustees set strategic policies and oversee operations. The CIA is the sole source of funds for In-Q-Tel at this time; however, the firm remains an independent entity.[4] Although In-Q-Tel does not require Agency approval for its business deals, which can include equity investments, contracts, and other partnering relationships, there is a significant amount of coordination between the CIA and In-Q-Tel on all business-related issues. The CIA does not have a typical "program management" oversight relationship with In-Q-Tel — the corporation makes decisions and provides the CIA with results. (Yannuzzi, 2000)

In-Q-Tel was designed to be an agile, flexible commercial firm that could work on its own terms with firms in Silicon Valley and throughout the world. The company has offices in Rosslyn, Virginia and Menlo Park, California. Currently, In-Q-Tel employs approximately 45 individuals (35 in Virginia and 10 in California) in three general areas: operations, technical, and venture. The relationship between the CIA and In-Q-Tel is acknowledged, and

work performed by In-Q-Tel, as well as its relationship with other firms and academic institutions, is generally unclassified.

THE IN-Q-TEL MODEL

The concept of operations for In-Q-Tel continues to evolve. The firm initially focused on the role of technology systems integrator; in this role, In-Q-Tel searched the marketplace for commercial off-the-shelf (COTS) technologies that could satisfy the Agency's needs (BENS, 2001). In-Q-Tel currently performs as a catalyst in developing technologies to solve specific CIA enterprise IT problems while simultaneously moving them into the commercial marketplace. In-Q-Tel leverages off of the commercial sector to satisfy the Agency's needs by providing input to promising technologies during the early stages of development. In-Q-Tel has the ability to partner with public and private companies worldwide, as well as with academic institutions and laboratories.

"The concept of operations for In-Q-Tel continues to evolve."

In-Q-Tel engages with the companies in a variety of ways, including work programs and equity investments. Investments typically range from $500,000 to $2.5 million in each company, with a total commitment of up to $5 million for the duration of the relationship (In-Q-Tel, 2002). Generally, In-Q-Tel is one of several venture capital firms investing in each IT company. In-Q-Tel has an expert in-house team that evaluates each technology through a rigorous technical review process

and provides feedback to the portfolio (IT) firm. Portfolio firms with successful technologies may enjoy a strategic advantage (resulting from In-Q-Tel funding, technical input, or the prospect of marketing their products to the CIA) as their products enter the commercial marketplace. Some versions of the commercial products that emerge typically have been or will be evaluated by the CIA. For its investment of up to $5 million through In-Q-Tel, the CIA's return may be a cutting-edge solution to an IT problem that uses technologies unlikely to be developed through federal funding alone.

"In-Q-Tel is a hybrid organization, combining various government and private sector models."

In-Q-Tel is a hybrid organization, combining various government and private sector models. Much like a government Research and Development (R&D) organization, In-Q-Tel is bound through a contract to only one customer, the federal government. However, as a lean commercial corporation, it is not limited by government bureaucratic constraints, civil service policies, or regulations and procedures.

In-Q-Tel characterizes itself as a "venture catalyst" rather than a venture capital firm, an expeditor of new technologies (In-Q-Tel, 2002). CEO Gilman Louie makes it clear that "[m]ost venture funds focus in on the business model...[w]e have a deep technical expertise...The most important thing is the technology return...[o]f secondary importance is the financial return" (Johnston, 2001, p. E5).

In-Q-Tel's investment in portfolio firms includes time and technical expertise, the unusual opportunity of allowing firms to test their technology using the CIA as a test bed, and funding. In addition to performing a review of each company's technology, In-Q-Tel also performs an in-depth review of each company's financial status before entering into a contractual arrangement to ensure that the company is financially sound. Depending on the circumstances, In-Q-Tel's contractual arrangements with portfolio firms can include one or more of several components: a software licensing agreement, an agreement that funds technology development or modification in accordance with a specific Statement of Work, and an equity investment in the firm (Richard, R. B. & Cook, K., personal interview, March 1, 2002). Approximately half of In-Q-Tel's deals include an equity investment (BENS, 2001).[5]

THE IN-Q-TEL OPERATIONAL MODEL

The In-Q-Tel Operational Model is comprised of four discrete entities: the CIA, QIC (In-Q-Tel Interface Center), In-Q-Tel, and commercial firms/academia (see Figure 1). The QIC, a 13-member organization, serves as the link — and often the "translator" — between the CIA and In-Q-Tel. As the interface organization, QIC ensures that the CIA's requirements are accurately identified before they are passed to In-Q-Tel; it is also responsible for the transition of commercial IT solutions from In-Q-Tel to the Agency.

The QIC manages contract administration and oversight of In-Q-Tel. The QIC and In-Q-Tel use a collaborative process, the "Q Process," for the development and execution of projects.[6] The "Q Process" is an eight-step process that begins with Step Q_0, Agency Needs Definition and
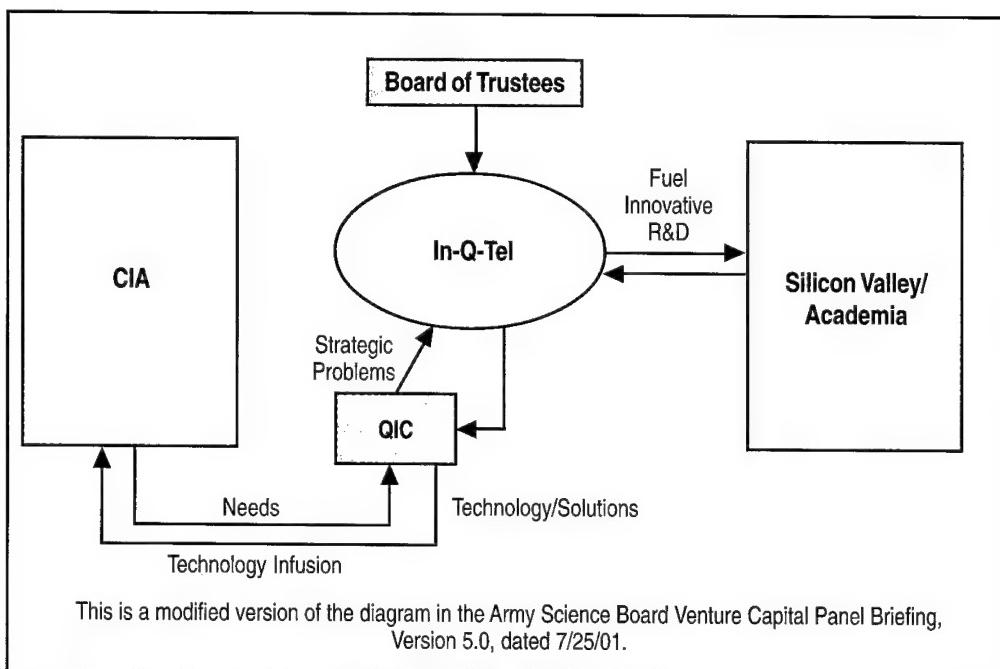
Figure 1. In-Q-Tel Model

moves through step Q_d, Deployment and Agency Acquisition, with several review boards and required approvals along the way.

During the Agency Needs Definition phase, the CIA develops strategic goals to pass to the QIC. Within the parameters set by the strategic goals, the QIC surveys users across the CIA to define the IT Problem Set for the fiscal year. The QIC then refines, prioritizes, and declassifies the Problem Set for submission to In-Q-Tel. In-Q-Tel searches the commercial markets to "landscape the technological 'spaces' that it plans on engaging to meet the Problem Sets" (BENS, 2001, p. A-1) and then invests in technologies from firms or academia that will satisfy an Agency Problem Set and also be viable commercial products.

Later in the process, In-Q-Tel tests the technologies against the Agency's needs, provides feedback to the firms,

and determines whether further funding for prototype development or a pilot program with the Agency is appropriate. In-Q-Tel actively advises the firms regarding commercialization of the products throughout the process. The final phases of the process involve transitioning technology solutions, via the QIC, to the CIA for integration into mission-critical systems. By the end of the process, an In-Q-Tel portfolio company will typically have a product with commercial potential.

Problem Sets are generally broad areas of interest. FY2001 Problem Sets included secure mobile office capabilities, Web discovery techniques, analytic tools and techniques, Internet privacy technologies, and collection technologies. Since September 11, 2001, there has been a shift to technologies that enhance intelligence efforts supporting the war on terrorism, accompanied by a dramatic increase in the

number of proposals and business plans submitted to In-Q-Tel.

Historically, In-Q-Tel receives approximately 600 business plans annually and provides funding to approximately 10 technology start-ups as a result. In FY2001, In-Q-Tel funded approximately $30 million for programs, pilots, and prototypes. CEO Gilman Louie estimates that approximately 80 percent of the companies funded by In-Q-Tel in 2001 had never done business with the federal government (Cortese, 2001). These firms include Mohomine, Intelliseek, Traction Software, Tacit Knowledge Systems, MediaSnap, and Browse3D. Between September and November 2001, In-Q-Tel received over 600 business plans (approximately the number of plans received during the previous year); a minimum of 15 technology investments was anticipated in FY2002 (Kady, 2001).

> **"Historically, In-Q-Tel receives approximately 600 business plans annually and provides funding to approximately 10 technology start-ups as a result."**

CORPORATE CULTURE

In-Q-Tel has achieved relative success over the past three years. In part, this has been due to the company's culture, which is energetic and creative. The current President and CEO, Gilman Louie, was previously a Silicon Valley entrepreneur, an executive at Hasbro Toys, and developer of computer games. Louie believes that In-Q-Tel will fail if it falls into the trap of becoming a government bureaucracy. Louie states, "I do not want this organization to be just another research organization that was created by the federal government, whose sole mission in life is to get bigger and get more dollars from the federal government...I want this to be very lean, very small, very quick-moving, with...people who don't want to make it a career" (Loeb, 2000, p. A-15). In-Q-Tel employees have diverse backgrounds, but their experience is overwhelmingly from the commercial sector. Many come from start-up companies, have worked for or consulted with the federal government, and have technical or business/law backgrounds.

In-Q-Tel's Web site (www.inqtel.com) stresses that the company is designed for agility, that employees who fill positions such as "Visionary Solutions Architect" are expected to stay with the company only three years before moving on, and that only the best and brightest are chosen to participate. The Web site describes the in-house technical teams as *swat teams*, the technologies In-Q-Tel invests in as *frame-breaking*, and states that *if your technology rocks...we'd like to talk to you.* In-Q-Tel is clearly working from a frame of reference that will appeal to the firms it hopes to attract.

In-Q-Tel's success can also be attributed to the fact that it has an office in Silicon Valley and proactively reaches out to firms with attractive technologies. In-Q-Tel does not merely issue a request for white papers and then wait for a response. The company receives proposals as a result of its Venture Capital Outreach program, from referrals, in response to newspaper and magazine articles, as well as through its public Web site. Finally, In-Q-Tel can offer firms technical advantages that they cannot find elsewhere: a rigorous technical review process, an

opportunity to use the CIA as a test bed, and the potential of partnering with and transitioning technologies to this "power user" in the intelligence community.

In their *Report of the Independent Panel on the CIA In-Q-Tel Venture*, submitted to Congress in June 2001, the Business Executives for National Security (BENS) stated, "the In-Q-Tel business model makes sense and its progress to date is impressive for a two-year old venture... In-Q-Tel's potential advantage to the CIA outweighs the risk. In-Q-Tel should continue as the CIA's entrepreneurial and innovative venture facilitating the delivery of new technology to the CIA" (BENS, 2001, p. v).

PROBLEMS WITH THE IN-Q-TEL MODEL

The BENS report indicated, however, that there was room for improvement in the In-Q-Tel model, particularly regarding the relationship and communication between In-Q-Tel and the CIA and the implementation of new technology within the CIA's business processes. Most of the problems cited were a result of inefficient government processes and security challenges associated with inserting tested technologies into CIA systems (software or hardware to be inserted must be approved by up to six review boards). Few problems were noted regarding the actual functioning of In-Q-Tel as a corporation, its relationship with outside technology firms, or its ability to attract and invest in new technologies.

The report did indicate, however, that due to ineffective marketing within the CIA, key users and stakeholders were

not fully aware of In-Q-Tel's capabilities. The BENS report recommended that a more proactive QIC could resolve the majority of these interface problems. The BENS report also recommended that In-Q-Tel not expand its mission beyond the CIA until it has been judged a success in its current mission, possibly upon the expiration of its charter agreement in July 2004 (BENS, 2001).

In response to the BENS report, the CIA has implemented several initiatives to streamline and expedite technology insertion into its IT architecture and aggressively market In-Q-Tel's capabilities within the Agency (Director of QIC and QIC Contracting Officer, personal interview, February 21, 2002). The QIC now informs users and stakeholders, early on, of promising technologies and solicits their input on the tailoring process. The newly consolidated Chief Information Officer (CIO) function at the Agency will also help coordinate and streamline the entire process, from the generation of Problem Sets to the final procurement of IT.

Most notably, the DCI has established an independent solution transfer fund specifically earmarked for establishing pilot programs, normally 12 to 18 months in duration, to implement new technologies within the Agency. A potential user is provided solution transfer funding to test a promising technology in his system; the user is not required to deplete his own budget to support the pilot program.

> **"The QIC now informs users and stakeholders, early on, of promising technologies and solicits their input on the tailoring process."**

If the pilot is successful, the Agency will issue a separate contract to buy the technology, either on a sole source basis or through a limited, best-value competition if more than one source is identified. Currently, there are seven active pilot programs within the Agency and three more to be launched. Finally, the QIC and In-Q-Tel are in the process of revising their performance metrics to focus on areas such as the acceleration of technology insertion rather than on the number of proposals received or the number of contracts issued.

"In-Q-Tel continues to evolve as a useful, effective tool for the CIA."

Despite the need for continuous improvement in the areas of coordination and communication with its customer, significant progress is being made in these areas. In-Q-Tel continues to evolve as a useful, effective tool for the CIA.

INTRODUCTION OF NEW TECHNOLOGIES WITHIN DoD

There are several organizations, programs, and authorities within DoD that were created to encourage commercial firms to partner with the federal government and to introduce new technologies to military systems. These arrangements have met with varying degrees of success. The Defense Advanced Research Projects Agency (DARPA), Federally Funded Research and Development Centers (FFRDC), and Research Laboratories are all chartered to develop state-of-the-art technologies.

The Small Business Innovative Research (SBIR) program and the Small Business Technology Transfer (STTR) program were established to provide cutting-edge technologies and innovative solutions to DoD by tapping small U.S. technology companies and research institutions. In order to ease burdensome statutory and regulatory restrictions associated with government contracting, 10 U.S.C. 2371 and Section 845 authorities were granted to DARPA, and ultimately the military services, to allow for the award of vehicles other than Federal Acquisition Regulation (FAR) contracts to firms that do not normally work with the government. Under 10 U.S.C. 2371, authority is granted to issue non-FAR agreements, termed "Other Transactions," for basic, applied, or advanced research. The National Defense Authorization Act for FY94, Public Law 103-160, Section 845 grants the authority to carry out prototype projects without applying several procurement-unique statutes.

The effectiveness of each of these tools in attracting cutting-edge, commercial technologies to the federal government, and how each compares to the In-Q-Tel model, is examined below.

ORGANIZATIONS THAT BRING NEW TECHNOLOGIES TO DoD

DARPA handles projects, each lasting an average of three to five years, designed to ensure that the United States maintains a lead in developing state-of-the-art technologies to meet military challenges of the future. In accordance with its charter, DARPA investigates ideas and performs fundamental research/development and prototyping efforts but does not carry these efforts through to production. Appropriately chartered DoD agencies must procure commercial or

military products that incorporate the technologies. DARPA establishes agreements with industry and educational institutions using FAR contracts as well as Section 845 prototyping agreements and Other Transactions (primarily for consortia arrangements). DARPA has had mixed success in attracting non-traditional firms to do government business.

The DARPA Web site, last updated in June 2002, indicates that the majority of recent Section 845 prototyping agreements were awarded to large traditional defense contractors (The Defense Advanced Research Projects Agency [DARPA], 2002). However, it is likely that small, commercial firms may be second- or third-tier subcontractors working under non-FAR agreements with the primes. Typically, universities lead the consortia under DARPA's Other Transaction arrangements; however, it is also likely that small, high-tech firms participate on the teams.

Clearly, DARPA and In-Q-Tel have significantly different missions. DARPA's role is to develop the very best technologies to support future military requirements, with possible commercial applications to follow. In contrast, In-Q-Tel's focus is to tap existing or potential commercial technologies that can be tested and used, in innovative and creative ways, to solve current IT problems within the Agency. In choosing technologies, commercial applications are key to In-Q-Tel, but not necessarily to DARPA. Based on the published statistics, DARPA tends to contract or establish agreements with traditional defense firms or universities rather than with small commercial firms; small commercial firms are potentially second- or third-tier subcontractors. To date, In-Q-Tel's commercial arrangements are solely

with high-tech firms. Although DARPA plays a critical role within DoD, it does not perform the same function for DoD that In-Q-Tel performs for the CIA.

FFRDCs are privately administered, nonprofit organizations sponsored by the government (DoD and civilian agencies), with restrictions on their activities to preserve their independence and objectivity. FFRDCs work as strategic partners with a sponsoring government agency, as well as with industry and educational institutions, to solve complex technical problems (BENS, 2001). FFRDCs are tied to government contracts, are part of the government culture, and tend to be too slow and bureaucratic to react flexibly to the dynamic environment that surrounds IT (BENS, 2001). Historically, FFRDCs hire engineers to work in-house — they rarely partner with non-traditional commercial firms. Although both In-Q-Tel and FFRDCs are nonprofit organizations bound to the federal government through contractual arrangements, they have radically different cultures and methods of doing business.

"Historically, FFRDCs hire engineers to work in-house — they rarely partner with non-traditional commercial firms."

Government, university, and corporate laboratories generally work on technical solutions in-house. Often development cycles are lengthy and costs are high. Laboratories provide new technologies to DoD in accordance with the terms of contracts, grants, or cooperative agreements; however, the mission of laboratories is generally different from In-Q-Tel's mission of partnering with commercial companies to leverage off of existing private

sector research and development (BENS, 2001). Most laboratories are more oriented toward developing an in-house product to satisfy a government requirement rather than seeking a commercial solution.

PROGRAMS THAT BRING NEW TECHNOLOGIES TO DoD

"The high-tech firms are primarily attracted by the technical review performed by In-Q-Tel and the prestige of having the CIA as a customer...."

The Small Business Innovative Research Program funds fundamental research and development projects that support DoD requirements and also have potential in the commercial marketplace. The firms solicited by DoD are small companies organized for profit that have a maximum of 500 employees. Awards are offered in two phases. Phase I awards are six months in duration and funded up to $100,000; Phase II awards are two years in length, funded from $500,000 to $750,000, and result in fabrication of a prototype. After Phase II, the firms must work independently to market their products for production. A survey of the firms that were awarded contracts over the past fiscal year reveals a mix of non-traditional and DoD small businesses participate in the program.

Congress established the Small Business Technology Transfer Program in 1992 to fund cooperative research and development projects involving small businesses and research institutions. The purpose of the program is to enable research institutions to move their technologies to the public and commercial sectors. The DoD STTR Program was funded at $31 million in FY2000 (Office of the Secretary of Defense, 2002).

Both of these programs function like In-Q-Tel in that they encourage non-traditional firms and research institutions to provide new technologies to the federal government. However, the SBIR and STTR programs require the issuance of government contracts and the transfer and obligation of funds, a time-consuming, rigid process at best. These government programs are not implemented with In-Q-Tel's speed and agility. In addition, In-Q-Tel searches out, funds, and tests only technologies that have definite commercial applications; the high-tech firms partnering with In-Q-Tel are expected to make significant amounts of money on the commercial market, much more than the limited amount of money that In-Q-Tel provides.

The high-tech firms are primarily attracted by the technical review performed by In-Q-Tel and the prestige of having the CIA as a customer, not the small amount of funding provided for research and development. This is not necessarily true of the companies responding to the SBIR solicitation, which may rely solely on government funding for their projects. Under the SBIR and STTR programs, the prerequisite for contract award is not commercial viability; government interest rests primarily with the military application of the technology.

EFFECTIVENESS OF DoD'S ORGANIZATIONS, PROGRAMS, AND AUTHORITIES

DoD has a number of tools — organizations, programs, and authorities — that have introduced new technologies into military systems with relative success.

However, none of these approaches has enabled DoD to leverage off of successful commercial technologies in the way that In-Q-Tel has worked for the CIA. In-Q-Tel represents a combination of government and commercial structures.

Although it is an independent corporation, it is contractually bound to the federal government much like the FFRDC model and its strategic objectives are intertwined with the strategic objectives of its only customer. Unlike any purely DoD organization or program, though, it has a commercial culture and extended reach into the commercial community. No DoD organization, program, or contracting authority fills the unique niche filled by In-Q-Tel. The addition of a "venture catalyst" firm to the current DoD structures would provide one more effective tool to enable the military to move into the information age.

ESTABLISHING A "VENTURE CATALYST" FIRM FOR DoD

When assessing the feasibility of establishing an entity based on the In-Q-Tel model, DoD must consider whether its establishment would conflict with any statutes or regulations, the cost of establishing a similar firm, and the organizational buy-in that would be required for success. Based on advice from internal attorneys, as well as an independent law firm, the CIA made the determination that In-Q-Tel lawfully could be formed, chartered, and funded with no special legislation other than the appropriation of funds (Director of QIC and QIC Contracting Officer, personal interview, February 21, 2002).

Norman Augustine and other private citizens formed In-Q-Tel with the understanding that it would specifically support CIA activities. The legal basis for its formation is the same as for any other nonprofit corporation. The Agency then chartered and funded In-Q-Tel through a government contract. The CIA's contracts with In-Q-Tel are based on the FAR, although the Agency relied on Section 8 of the CIA Act of 1949 to waive certain provisions that otherwise would have applied. The CIA believes that funding an organization like In-Q-Tel using 10 U.S.C. 2371 authority would allow even more flexibility, since under Other Transactions, most FAR regulations are optional, intellectual property provisions can be crafted, and most procurement-specific statutes are waived. It appears that there are no statutes or regulations that would prevent DoD from establishing an In-Q-Tel type arrangement.

According to the BENS report, total General and Administrative costs for In-Q-Tel were approximately $12.6 million for the first year, including start-up costs of approximately $2.5 million, and annual recurring costs, including salaries for employees and compensation for Board Members of approximately $10.1 million (BENS, 2001). In order to establish an In-Q-Tel-like entity, DoD would need approximately $13 million for start-up and administrative expenses as well as additional funding for mission delivery (programs, prototypes, etc.), equity investments,

> "No DoD organization, program, or contracting authority fills the unique niche filled by In-Q-Tel."

and miscellaneous items. Total CIA funding for In-Q-Tel was $28.7 million in FY99, $37.27 million in FY00, and $33 million in FY01 (BENS, 2001).

QIC and In-Q-Tel employees provided the following "lessons learned" that might be valuable to a government agency:[7]

- Establishing a business and operational relationship with a firm like In-Q-Tel is not easy. You need support from the Head of the Agency down the chain of command. Everyone needs to be committed to success.

- You need the ability to think outside the box and manage rather than avoid risk.

- Initially, you must start with a well-defined, bounded set of technologies to go after. You can always expand the Problem Set to incorporate new technologies later.

"You need the ability to think outside the box and manage rather than avoid risk."

- Your organization may need a culture change — if you are going to insert new technologies from the outside, the idea that "if it isn't developed in-house it isn't good" must change.

- When starting to work with this type of firm, limit your technologies. At first, pick a well-defined technology that is somewhat easier to transfer to ensure success. Once you pick the technology, pick members for the

Board of Directors who have expertise in the technology areas.

- Remember that a company like In-Q-Tel has a high overhead and is human- capital intensive, because of the cadre of engineers who test technologies. If the technology is less complex, the overhead may be reduced.

- Once a decision is made to establish a company like In-Q-Tel, commitment and patience is necessary.

In order to manage risk, avoid pitfalls, and benefit from lessons learned, an organization choosing to establish an entity similar to In-Q-Tel should consider consulting with (or even employing) experienced CIA and In-Q-Tel personnel to establish a business plan geared toward success.

RECOMMENDATION

Establishing a "venture catalyst firm" would greatly benefit DoD by providing a new approach to developing and inserting commercial technologies into military systems. As an addition to rather than a replacement for existing programs and authorities, this model would enhance DoD's ability to attract and tailor new technologies to provide innovative solutions; establish an efficient, flexible conduit for contracting with cutting-edge firms; enable DoD to leverage off of the commercial sector technologies that might not be available within the limitations of the federal acquisition

system and with federal funding alone; and further encourage development of dual use technologies.

This model applies not only to IT, but also to other commercial technologies that support the DoD mission. There are no readily apparent legal or financial barriers, provided that funds are appropriated, that would prevent DoD from establishing an arrangement similar to the arrangement between the CIA and In-Q-Tel. The stumbling block is whether or not DoD has the ability to transform its culture to accommodate the innovation, risk, and flexibility that must accompany this new approach to technology insertion if it is to succeed.[8]

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ENDNOTES

1. In January 2001, the BENS established and supported an independent panel to assess In-Q-Tel's strategy, structure, processes, technologies, and legal foundation. This assessment was required by a Congressionally Directed Action in FY2000 Conference Committee markup language, to perform "an independent cost versus benefits assessment" of CIA's In-Q-Tel venture. The panel's report was submitted in June 2001 (BENS, page iii).

2. Quoting Charter Agreement, July 1999. The Charter Agreement has since been amended.

3. Quoting Charter Agreement, July 1999. The Charter Agreement has since been amended.

4. A detailed discussion of the contractual and funding arrangements between the CIA and In-Q-Tel is found in the section of this paper entitled, *Establishing a "Venture Catalyst" Firm for DoD.*

5. Although In-Q-Tel has not yet seen a major Return on Investment, a Memorandum of Agreement between In-Q-Tel and the CIA defines the allocation of profits traceable to CIA funding: 50 percent of profits go to In-Q-Tel Problem Sets and 50 percent to strategic IT initiatives defined by the CIA.

6. The eight steps of the "Q" Process, although all are not addressed in this paper, are as follows:
   Q_0 Agency Needs Definition
   Q_1 Portfolio Management
   Q_2 Contracting
   Q_3 Contract Definition and Demo
   Q_4 Prototype and Test
   Q_p QIC/IQT Piloting
   Q_b End-User Piloting
   Q_d Deployment and Agency Acquisition (BENS, Appendix A).

7. Interviews with Director of the QIC and QIC Contracting Officer, February 21, 2002 and Interview with Chief Operating Officer and Director, Technology Assessment at In-Q-Tel, March 1, 2002.

8. The Department of the Army is currently considering this issue. The Army Science Board Venture Capital Panel issued a report on July 25, 2001 stating that existing programs and authorities provide enough flexibility to introduce state-of-the-art, critical technologies to the Army. However, the FY02 DoD Appropriations Bill and Congressional language earmark $25 million for the purpose of establishing a venture capital investment corporation for the Department of the Army. The Army is currently assessing the risk of establishing this type of entity and attempting to define a technology problem set (Army Science Board Venture Capital Panel briefing, Version 5.0, dated July 25, 2001).

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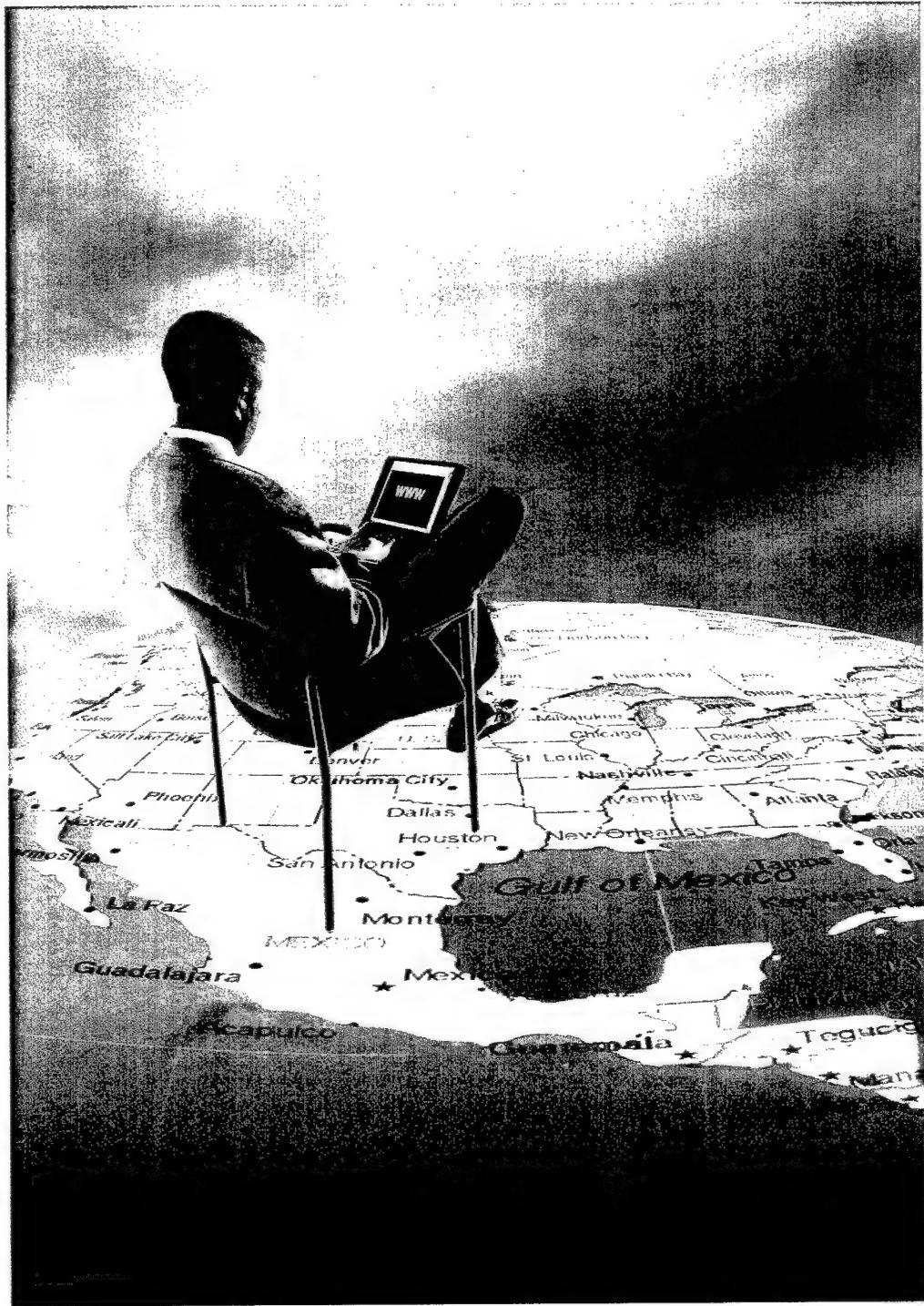
PROGRAM PLANNING OF ASYNCHRONOUS ON-LINE COURSES
DESIGN COMPLEXITIES
AND ETHICS

Jay W. Gould III

The advent of the World Wide Web provided the feasibility of instant feedback between student and instructor analogous to the teaching methodology of ancient Greece. However, modern lecture halls or classrooms notably diminish the student's knowledge expectancy, suggesting a normal distribution curve. Research results affirm that learning is the sole responsibility of the student. However, unless the design team responsible for developing the distance education course addresses on-line variances and the instructors acknowledge their responsibility to provide motivation by putting a personal instructional touch into the "tube," the attainable two-sigma shift to the right will not be achieved. Therefore, has the Web's distance asynchronous on-line instruction defined a solution for the long-held dilemma of finding an educational methodology that will achieve results analogous to tutorial education and, if so, under what conditions would those similar results be achieved?

According to Joel Barker (1997), "When a paradigm shift occurs everyone is set back to zero." Digital age technology has affected every stakeholder in adult education and added some new players never before involved in the process. Software technologists, service technicians, on-line mentors, learning specialists, and possibly psychologists have been added as stakeholders, a group that already includes teachers, students, and institutional administrators.

During the 7th Hong Kong Web symposium, panel moderators Nigel J. French and W. F. Massy (2001) conducted an international virtual panel discussion, an interchange of ideas, on how to face the on-line educational challenges of the 21st century. The primary challenge was to provide access to a wider range of students from varying educational and ethnic backgrounds and afford them the opportunity to perform on an even playing field, while at the same time reducing student

costs. The conference featured a simulation game for program planners to compete on methods for handling the shrinking resident course and campus infrastructure needs while expanding campus Internet technology and security. A significant part of a program planner's design is to resolve issues pertaining to the technological net, servers, security, Web support, hosts, and operating systems (French & Massy, 2001).

Not everyone agrees that on-line distance learning is the freight train coming down the track. A February 2001 broadcast of the news show *60 Minutes* contrasted traditional universities such as Harvard, Yale, and Stanford with profit universities such as University of Phoenix, Jones University, and Capella University. Dr. Carole Fungaroli-Sargent, Georgetown University professor of English, gained her 15 minutes of fame in her interview by proclaiming, "[Your education] is the same as sex on the Internet. You can get it on-line, but it's a lot better in person" (Hartman, 2001).

"Not everyone agrees that on-line distance learning is the freight train coming down the track."

Although Fungaroli-Sargent's comments addressed growing concerns regarding on-line distance learning in a more humorous light, there are general beliefs that stem from fear that information technology (IT) usage for educational purposes will result in the loss or replacement of human contact. Subsequently, the increase in the use of adjunct professors and teaching assistants could result in the laying off of traditional faculty.

"This fear [is] expressed in a variety of ways [through] the American Federation of Teacher's [1999] ad campaign about the 'Five Minute University,' the breakdown-in-community argument; and the no-proof argument — 'no one has shown that technology can improve learning.' Since education is a human or social practice, and it has primarily been practiced in face-to-face settings, physical contact becomes the primary enabler of learning" (Twigg, 1999, p. 5). But do these thoughts support beliefs that asynchronous learning may be less effective?

For instance, the efficacy of asynchronous on-line education has been challenged. Research conducted at the University of Central Florida by Dr. Charles Dziuban and Patsy Moskal (2001) indicates there is no significant difference between face-to-face and on-line distance learning.

Kristin Hasselbrack presented a paper at the 2001 Interservice/Industrial Training, Simulation and Educational Conference suggesting that if an on-line course was facilitated in a manner defined in Benjamin S. Bloom's (1984) research, the average student could be moved a possible two sigma to the right of the mean (Hasselbrack, personal communication, December 3, 2001). Program planning for on-line courses is changing dramatically — precipitated by the impact of technology, a population of students growing asymptotically, teacher fear, and institutional resistance to change.

PARADIGM SHIFT IN EDUCATION

For centuries, teachers trained in the tutorial educational methods of Socrates and Plato had a significant emotional event when Gutenberg's textbooks expanded the

educational system. The oldest guild in Europe saw its educational precepts change from tutoring one-on-one to teaching groups of students in the classroom lecture halls. Learning shifted from being experiential — learning from the master, to the students learning from each other, to the sage on the stage — where much of the responsibility for student learning was placed upon the capability of the lecturer. Learning in this format required the presence of the student in the lecture hall. Great learning institutions, "ivy towers of intellect," were built and worshipped as hallowed institutions.

Those who could not attend became part of the uneducated masses. Various attempts were made to broaden the field and provide access to a greater population of learners by utilizing media different than the human voice in the lecture hall or classroom. Some of these adventures were correspondence schools, radio lectures, television broadcasts, and closed-loop television hookups. Cassette tapes, videotapes, and CD ROMs added to the milieu, but nothing really provided that paradigm shift that would and could bring about worldwide education by expanding educational availability to large numbers of people distant from the subject matter experts.

To understand the impact on educational program planning, the series of events that gave life to on-line education must be examined. The inability of educational institutions to fulfill the needs of a worldwide student population remained in a static condition until a change of events occurred at the opposite end of the country. The paradigm shift in education would cause the ivy towers of intellect to crack and lose mortar where some are

predicting the walls will "come tumbling down" to the clarion call of the World Wide Web's trumpet of asynchronous on-line learning. The Sloan Foundation's philanthropic interest in funding family's efforts to move up the economic scale and the technology of the digital age were melded together providing the structure for this dramatic change in educational instruction (Mayadas, 1997).

CAUSE AND EFFECT

Stanford University formed the backdrop for the creation of the World Wide Web. Tim Berners-Lee and Robert Cailliau, Conseil Européen pour la Recherche Nucleaire (CERN) engineers searching for a way to exchange information and data between nuclear scientists, documented in detail a "hypertext" project proposing a descriptive catch word, World Wide Web, complete with a uniform resource locator (URL), hypertext transfer protocol (HTTP), and hypertext markup language (HTML) standards with prototype Unix-based servers and browsers (Gromov, 1995). These events defined the invention of the Internet, the foundational base of asynchronous on-line education.

> **"Great learning institutions, "ivy towers of intellect," were built and worshipped as hallowed institutions."**

New enterprises require money. The details of the Sloan Foundation's granting of seed money are defined in the Sheffield Lecture series. In January 2000, Dr. Ralph E. Gomory (2000), president of the Sloan Foundation gave the Sheffield Lecture at Yale entitled, "Internet Learning: Is

It Real and What Does It Mean for Universities?" Gomory cited the lessons learned in the following statement:

While the Asynchronous Learning Network (ALN) is an attempt to reproduce the basic elements of classroom teaching, it is certainly not the same as classroom teaching. For those who teach ALN classes, teaching will be different....

We have learned that if homework is constructed to be instantly electronically corrected and returned it can be an important learning tool; we have also learned that inadequate training on the fundamentals of the underlying software can lead to the disappearance of a large portion of a class, before learning about the course material itself has even begun.... It is the pedagogy that counts....

"In on-line courses, the subject matter expert is part of a team comprised of an experienced on-line faculty program planner, Web technician, software programmer, editor, copyright expert, and an independent evaluator."

Often the current providers are much slower to react, due to internal organizational and personal reasons, the fear of cannibalizing their own business, or various forms of denial.... By making learning outside the classroom heroic, we can make it what it ought to be, an ongoing part of ordinary life (Gomory, 2000).

The experience utilized for the citation of the lessons learned were based upon the experiences of Dr. Frank Mayadas (1997), hired by the Sloan Foundation after retiring from IBM in 1992. Dr. Mayadas became the program manager for the birth of asynchronous distance learning on the Internet, and the University of California at Berkley received the first seed money to launch ALN in 1993.

Since then, over 100,000 students have enrolled for the ALN experience with more than 4,000 faculty-semester hours invested. Pennsylvania State University (PSU) was given seed money for its ALN adventure in 1994.

The Sloan Foundation was not alone in the philanthropic movement for greater access to education. The Pew Symposia sponsors "an on going national conversation about issues related to the intersection of learning and technology that places the discussion in the context of student learning and ways to achieve this learning cost effectively" (Twigg, 2001).

The Olin Foundation provided funding for Vanderbilt University to develop a program-planning guide for on-line courses. Drs. John Crocetti and John Borne, in conjunction with Dr. Eric McMaster of Wild Dog Technology LLC, presented their work at the Sloan-C6 International Conference on Asynchronous Learning Networks at the University of Maryland on November 3, 2000. Their work was presented as a pre-conference workshop, "Strategic Planning for On-line Courses." The workshop cited an absolute requirement for immediate student electronic feedback and covered every aspect associated with program planning for an on-line course.

In resident lecture-hall courses, the subject matter expert is the professor delivering the lecture. In on-line courses, the subject matter expert is part of a team comprised of an experienced on-line faculty program planner, Web technician, software programmer, editor, copyright expert, and an independent evaluator. The conversion of the traditional 30-hour quarter, three-hour resident course requires 200 to 300 total team hours to obtain an asynchronous on-line

student-centered virtual learning community. In turn, the hours required for the initial development of a new course, not previously given, is estimated to be 480 hours of faculty time. However, by the second year the course is offered, other than the on-line mentor time, the course will require approximately 20 hours of faculty maintenance excluding other members of the team (Bourne, Campbell, & McMaster, 2000).

WEB-BASED ASYNCHRONOUS ON-LINE MOTIVATIONAL PROGRAM PLANNING

The literature, whether it is a published book, referred journal, seminar/symposium proceedings, or a published paper available through the Web or Educational Resources Information Center (ERIC), supports the consideration that on-line educational programs are significantly different from resident courses. Resultantly, the program planning techniques suggested for achieving satisfactory results are also significantly different than the time-honored models sometimes utilized by resident course authors. However, there is a significant caveat. Ivy towers of intellect have existed for over 650 years. In that time frame, there has been sufficient opportunity to perfect the program planning process.

From its birth in 1993 at Berkley, on-line asynchronous education is only eight or more years old at the most, a total infant by comparison. The pioneers of this new methodology of dispersing education to the population as a whole are brimming with different ideas as to the model that might be used to place the converted resident course or newly conceived on-line course on the path to noteworthy success. The older models carried over from the resident course days, unfortunately, do not adequately address the significant number of nuances, idiosyncrasies, and changes in paradigms on-line education carries with it.

The field is populated with specialists examining different ways to enhance and better their own educational or technological nitch. Some books are the result of an aggressive editor who collects published papers from many authors to present views on the changing education paradigm. One such text is *Web Based Instruction,* edited by Badrul H. Khan (1997). Chapter 11 by Richard Cornell and Barbara L. Martin (1997), "The Role of Motivation in Web-Based Instruction" states, "As many as 30–50 percent of all students who start

"The field is populated with specialists examining different ways to enhance and better their own educational or technological nitch."

a distance education course drop out before finishing" (Moore & Kearsley, 1996, p. 93). To counter the high dropout rate, they posit the Keller Motivational Design Model originally developed in 1983 and later adapted to Web-based courses in 1993 by Keller and Burkman as a method of continuous motivational reinforcement throughout. This responsibility is assigned to the course developer of the program plan. Key motivational principles and course design strategies for Web-based courses are "Variation and Curiosity, Relevance, Challenge Level, Positive Outcomes, Positive Impression, Readable Style, and Early Interest" (See Appendix for details; Keller & Burkman, 1993, pp. 96–98).

Student motivational program planning cannot be overstated. For a Web-based course to be successful, at any institution, the Keller and Burkman Motivational Design Model should be followed.

Cornell and Martin offer some sound thoughts for the instructor converting a course from residency lecture to an asynchronous on-line status:

1. Re-tooling establishes the wrong mind-set. The possibilities and constraints of teaching via the Web are quite different from those used in traditional classroom delivery. If the class is destined for Web delivery, consider it an opportunity to rethink the entire class from beginning to end, addressing not only the methods to be employed but also the content.

"Student motivational program planning cannot be overstated."

2. Seek the opportunity to redesign the course well ahead of the time it is due to be taught. Teaching a Web-based course is not just a re-do of what has been taught in the past. Suggest to the department chair that using the Web will require the acquisition of a new set of teaching skills, including sufficient time to search for sources on the Web, locate those not on the Web, and integrate them into the course design.

3. Realize that using the Web to deliver instruction will, at least initially, take far more time, not less; that the time communicating with students will increase disproportionately as compared with the time spent in the traditional classroom.

4. Use this new teaching assignment as a means to obtain a new computer to conduct class via the Web....

5. Identify who among the students is skilled in using the Web for other purposes and let them assist. Admit a learning deficit (related to technology) to the class as, together, we will all learn how to use this new method of instruction.

6. Find others who have been asked to teach via the Web. Join with them as they learn the techniques, or ask for their insights if they have prior Web-based teaching experience.

7. If the institution has asked you to teach via the Web, it is likely that the agency has a faculty development center or office of instructional resources. Within these facilities is a team of experts able to assist (Cornell & Martin, 1997, p. 99).

Colin McCormack and David Jones hold, "The greatest benefits of Web-based classrooms occur via a pedagogy that most effectively uses the characteristics of the technology to increase quality of the learning experience" (McCormack & Jones, 1998, p. 23). The responsibility for learning in Web-based courses shifts from the instructor to the learner. With the student motivational methodology suggested by Keller and Burkman and program planning team following the suggestions of Cornell and Martin, a course quality increase is assured as well as a motivated enrolled student.

STUDENT POPULATION SERVED

"There are at least three typical global higher education student profiles. One is Asian as its dominant trait; another is over 23 years of age; and the third holds an associate-equivalent or bachelor's degree and either has been or is about to be 'downsized' from a job" (Jones, 1997, p. 4). The author goes on to remark, "We are coming to understand the concept of 'life-long learning.' Indeed, lifelong learning has moved from the category of 'discretionary' personal investment to 'essential' as people scramble to bolster their credentials in a volatile global market place" (Jones, 1997, p. 5).

Rena M. Palloff and Keith Pratt have observed, "Much of the research done on successful students in distance education programs suggests that students who are attracted to this form of education share certain characteristics, including that they voluntarily seek further education, are motivated, have higher expectations, and are more self-disciplined" (Palloff & Pratt, 2001, p. 109). Learners assuming control over their learning encourages independent thinking, it "is a combination of computer mediation, platform, and geographic and temporal independence" (McCormack & Jones, 1998, p. 22).

THE 2 SIGMA QUESTION

Since the advent of distance learning, research has been done to determine whether or not students were learning. Whether it was a correspondence course, radio broadcast, video, television broadcast or closed-loop activity, CD Rom, or E-learning, the answer to this question for the most part has always been the same — no significant difference.

Thomas L. Russell has been tracking the "No Significance Phenomenon" from 1928. Russell lists a significant number of research studies where the phenomenon is true. Companion to this site is a lesser listing of research studies where there is a significant difference. The majority of these research studies found that on-line education is better than face-to-face. In a very few cases the opposite is true (Russell, 2002). The research effort is turned to how to develop an on-line educational system that achieves the coveted goal of a two sigma shift to the right.

"Whether it was a correspondence course, radio broadcast, video, television broadcast or closed-loop activity, CD Rom, or E-learning, the answer to this question for the most part has always been the same — no significant difference."

Benjamin S. Bloom (1984) raised the two sigma question in his paper, "The Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring." Bloom accomplished a critical analysis of completed dissertations of two students at the University of Chicago. The conditions of instruction were compared — conventional, mastery learning, and tutoring. Striking differences in final achievement were measured. "It was typically found that the average student under tutoring was about two standard deviations above the average control class." Further, "mastery learning was about one standard deviation above the control class" (Bloom, 1984, pp. 4–16).

From a very negative view teaching a positive solution, Edward L. Vockell (1994) published a paper entitled, "The Minus Two-Sigma Problem: Defective Instruction." Reviewing the poor teaching methods of a ninth-grade English teacher, Vockell defined selected alterable variables that influence student achievement.

At the 2001 Interservice/Industry Training, Simulation, and Education Conference, Kristin Hasselbrack's presentation suggested the achievement of a two sigma shift was most probable with asynchronous on-line learning where the program planning and implementation aided cognitive development and critical thinking (Hasselback, personal interview, December 3, 2001).

In "Innovations in On-line Learning: Moving Beyond No Significant Differ-

ence," Carol A. Twigg (2001) cites differences between the old paradigm community investments of time and energy in old rules and the paradigm shifters she calls the "new providers." Case after case is presented defining how "ground breaking" occurs as some colleges and universities become "pace setters" toward greater individualization of students.

Of particular note was a small Arizona college, Rio Salado at Tempe. In personal emails, Karen Mills provided aspects of Rio Salado's approach.

The goal is to show that it's not providing student service on-line; it's how you provide student services on-line. The faculty service department (26 people) recruits, trains, and assigns 750 adjunct faculty to work with full time faculty. A student who needs an on-line

ON AVERAGE, TUTORED STUDENTS SCORE BETTER THAN 98% OF CLASSROOM STUDENTS – A 2-SIGMA SHIFT

Students

2σ

Classroom Students

Tutored Students

Achievement

Adapted From: Bloom, B.S. The Two Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring. Educational Researcher. 13, 4-16 (1984)
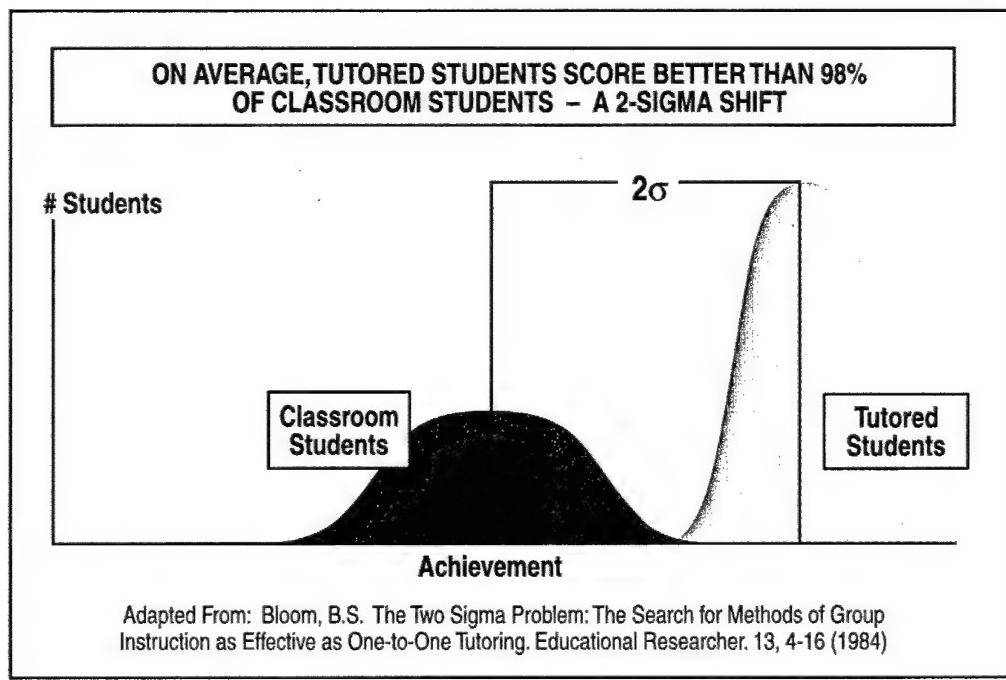
**Figure 1.
Achievement Comparison of Classroom Students vs. Tutored Students**

tutor informs the service department, the tutor is beeped and within two hours of the page, seven days a week, fourteen hours a day, the student has a tutor answering his/her need. Information services have voice mail boxes complete with 800 numbers for students and faculty. Under certain conditions it is possible for tech services to actually take control of the distant learner's computer key board to help solve problems" (Mills, personal communication, March 2002).

On-line learning is an infant industry that was born weighing in at 800 pounds. The axiom of new business ventures is, "Find a need and fill it." The world population needs education that is ethical, practical, and timely. On-line education can fill that need if program planning like that conducted at Rio Salado College is accomplished. Rio Salado recognized that the student is the customer not the sponsoring institution, educational course, or professor, by embracing the quality vigorously espoused by the late Dr. W. Edwards Deming (1986) in his book, "Out of the Crisis."

The university and college educational system in the United States and in the world is in a crisis. The Pew Grant Program in Course Redesign defines five key features that can improve the quality and ethics in student learning:

1. An initial assessment of each student's knowledge/skill level and preferred learning style.

2. An array of high-quality, interactive learning materials and activities.

3. Individualized study plans.

4. Built-in, continuous assessment to provide instantaneous feedback.

5. Appropriate, varied kinds of human interaction when needed.

CONCLUSION

The Pew Grant Program in Course Design (Program Planning) is fully endorsed and embraced. Rio Salado College is openly commended for breaking new ground in program planning, recognizing student's tutor needs and answering the beeper within two hours, seven days a week, and 14 hours a day with a staff of 750 adjunct faculty. If the standards of Socrates and Plato are to be obtained, they are only achievable when students are responsible for their own learning and the on-line educational system is structured to aid their quest.

The literature supports the consideration that adult students are willing and able to learn. The caveat is unless the motivational aspects outlined by Keller and Burkman are followed, the isolated student will feel abandoned and, suffering anaclitic depression, will most likely quit the course. The Program Planning team must also be motivated along the lines offered by Cornell and Martin. If the Program Planning team does not satisfactorily accomplish its effort in course redesign, asynchronous on-line students will gravitate to those colleges and universities who practice setting the paradigm back to zero.

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APPENDIX

COURSE DESIGN CONSIDERATIONS
Principles and Motivational Design Strategies

Variation and Curiosity

1. Make changes in organization and presentation of content to stimulate attention and curiosity.
2. Provoke mental conflict by introducing problems to be solved and contradictory facts.
3. Engage in Internet-based competitions between students in class as well as those located in other classes or at other institutions.
4. Develop diversity of Web-based products, which appeal to different learning styles.

Relevance

1. Build a strong relationship between what is being learned and the objectives of the course.
2. Show how the instruction relates to what the learner already knows.
3. Show how the instruction relates to the student [SIC] future goals.
4. Adapt course requirements to the learning style of students.
5. Be an enthusiastic instructor who is also in the process of learning new things.

Challenge Level

1. Include a student study guide with the following:
   a. Advance organizer to show students where they are going and how to get there.
   b. The goals and performance requirements.
   c. Student selected goals and learner options for activities.
2. Provide opportunities for students to interact with the instructor, other students, and the instructional materials.
3. Provide short segments of instruction.
4. Provide frequent summaries and reviews.
5. Provide frequent conformational and corrective feedback.
6. Have students submit work early in the course.
7. Ask students to overtly state their intention to finish the course.

Positive Outcomes

1. Provide the opportunity for students to use the new skills and knowledge learned during the course.
2. Reward accomplishment by using positive feedback.
3. Use extrinsic rewards (games with points, privileges, or tokens) to sustain motivation.
4. Share work done on Web with others, especially those at other institutions.
5. Encourage collaboration between students as they develop Web-based assignments.

Positive Impression

1. Make the initial perception of print courseware seem easy, rather than difficult. For example, teach students how to use appropriate search strategies to navigate the Web.
2. Make the instructional text well organized.
3. Make the physical attributes of the product consistent with learner expectations through instruction related to good graphic and text design principles, i.e., use of white space, complementary colors and background, limited use of visuals, plain typeface and font, etc., in materials produced for the course.
4. Use graphics, pictures, maps, charts, etc., that make the information easier to understand and to hold the students' attention. The most effective pictures include people in color and include novelty and drama.
5. Organize a Web contest to be judged by a panel of technologists who have an interest in both the mechanics of Web design as well as the aesthetics.

Readable Style

1. Use active voice and action verbs.
2. Use sentences that are moderate length.
3. Vary the vocabulary.

Early Interest

1. Create interest in the instruction as early as possible.
2. Provide opportunities early in the instruction to interact with others and with the instructional materials (Khan, 1997, pp. 96–98).

MANAGING THE DEVELOPMENT OF TECHNOLOGY-BASED COURSES SUCCESS FACTORS FROM EIGHT GOVERNMENT TRAINING COURSES

John Bennett, Ellen Bunker, and Kurt Rowley

A study was conducted to determine whether success factors identified in traditional higher education distance learning research literature were important to technology-based course development efforts at Defense Acquisition University (DAU). The study included a literature review, a list of candidate success factors from the literature, data collected through interviews with eight faculty course development managers, and data analysis to correlate findings with the research literature. The study indicates that many of the success factors found in the literature were also important to management of the DAU course development projects. A number of additional success factors identified were important for the DAU courses and may be important for other distance education development environments. Recommendations for development managers of distance education courses are proposed.

Defense Acquisition University (DAU) is a corporate university charged with training the Department of Defense (DoD) acquisition workforce. This study investigated success factors for managing the development of eight technology-based courses at DAU and identified success factors that may be relevant to ongoing and future DAU course development efforts. The courses studied (see Table 1) range from entry- level courses taken on-line with no required instructor interaction to higher-level courses using sophisticated threaded storylines and hybrid (on-line and classroom) components. These eight courses were selected because they are representative of the courses that won DAU two consecutive U.S. Distance Learning Association (USDLA) Awards for Excellence in Distance Learning Programming for 2000 and 2001. In addition, they have been successfully deployed, meet or exceed all educational and administrative requirements, and cover the range of instructional designs and delivery modes DAU uses in most of its courses.

Table 1. DAU Course Summaries

Course	Students per Year[1]	Course Hours (Online/ Classroom)[2]	Development Time[3]	Training Certification Requirements Met	Course Description
Fundamentals of Systems Acquisition Management (ACQ 101)	10,500/yr	25/0	13 months (Oct 97-Nov 98)	Level I DAWIA* training certification in Acquisition Management. Required course for multiple career fields	• Integrated entry-level course covering eight functional career fields. • Lessons and exams accessed via the internet.
Intermediate Systems Acquisition Course (ACQ 201A/B)	5,000/yr	40/36	18 months (Jul 99-Mar 01)	Level II DAWIA* training certification in Acquisition Management. Required course for multiple career fields	• Intermediate level integrated course. • Scenario-based hybrid design using both internet-based and classroom (5 days) delivery modes.
Introduction to Acquisition Workforce Test and Evaluation (TST 101)	2,000/yr	30/0	18 mos (Jan 99- Oct 00)	Level I DAWIA* required training certification for Test and Evaluation career field	• Entry level course with lessons and exams accessed via the internet.
Basic Software Acquisition Management (SAM 101)	700/yr	19/0	10 months	Does not provide DAWIA* training certification (course targets students from all DAWIA* career fields and levels)	• Internet-based distance learning course for all levels of learners. • Not a certification course.
Program Manager's Tools Course (PMT 250)	720/year	56/24 (Virtual Classroom)	3 months for 65% solution, 7 months for 85% solution	Level II DAWIA* training certification in Program Management career field	• Unique hybrid design. • Internet based DL (8 lessons) followed by synchronous four-day virtual classroom using phone conferencing and LMS file sharing tool (Forum).

[1] Students per year figures are approximate.

[2] Course hours based on course design estimates.

[3] Development time obtained from Course Manager interviews. Generally, from the time the development contract was awarded to the start of the first production offering.

* Defense Acquisition Workforce Improvement Act (DAWIA)

** Business, Cost Estimating, Funds Management (BCF) functional area

Note: 100 series courses are entry-level, 200 series courses are intermediate level, and 300 series course are advanced level.

(continued)

Table 1. DAU Course Summaries (continued)

Course	Students per Year[1]	Course Hours (online/ classroom)[2]	Development Time[3]	Training certification requirements met	Course Description
Program Management Office Course (PMT 352)	700-1000/yr (first offerings started in June 02)	50/232	18 months total (DL fielded in 12 months)	Level III DAWIA* training certification in Program Management career field	• Hybrid design. • Integrated advanced-level course. • 10 modules of internet-based distance learning. • 12 scenario-based exercises over six weeks in the classroom. • LMS used to access classroom material and exams.
Fundamentals of Earned Value Management (BCF 102)	700/yr	60/0	About 20 months	Level I DAWIA* training certification in BCF** career field	Internet based distance learning modules for entry-level instruction in Earned Value Management
Acquisition Business Management (BCF 211)	170/yr	20 to 30/37	About 8 months	Level II DAWIA* training certification in BCF** career field	• Hybrid design, intermediate level course. • Students must pass three tests online within 60-day window. • Review material (no structured lessons) provided online as prerequisite to five-day classroom portion.

[1] Students per year figures are approximate.

[2] Course hours based on course design estimates.

[3] Development time obtained from Course Manager interviews. Generally, from the time the development contract was awarded to the start of the first production offering.

* Defense Acquisition Workforce Improvement Act (DAWIA)

** Business, Cost Estimating, Funds Management (BCF) functional area

Note: 100 series courses are entry-level, 200 series courses are intermediate level, and 300 series course are advanced level.

The process for managing the development of these courses mirrors the weapons system acquisition process. Both start with requirements generation and progress through concept, design, content development and programming, testing, and deployment. Interviews with the eight course development managers (all DAU faculty members with practitioner experience in systems acquisitions),

confirmed that many of the course development success factors are directly related to commonly accepted systems acquisition and program management techniques.

The distance education literature reports many success factors related to managing the development of technology-based university-level courses. Those most commonly cited include effective use of changing technologies, sufficient resources for course development and operation, creating educationally sound and engaging course designs, effective staffing, detailed planning, identifying and accommodating the needs of instructors and students, and ensuring sufficient technical expertise.

"The researchers used success factors described in distance learning research to help guide data collection."

Much of the existing information focuses on technology-based traditional university training. Compared to traditional universities, corporate universities face unique challenges. Because the corporation typically pays employee salaries while they are students at the corporate university, the training must be as efficient as possible. Also, the training investment is expected to transfer directly into job performance. These are strong incentives for creating effective learning environments that minimize employee time in the training environment.

The researchers used success factors described in distance learning research to help guide data collection. Interviews were conducted with the DAU course development managers, followed by analysis of data. The success factors identified from the literature review were then compared with success factors developed from the DAU interviews to determine which factors are common to both and which are unique to DAU. A set of proposed recommendations for distance learning program managers was developed from the results of the study. The study provided a strong grouping of success factors and recommendations that should apply to DAU as well as to management of the development of distance learning courses at similar institutions.

BACKGROUND

From the inception of formal DoD systems acquisition training in 1971 until the late 1990s, students have traveled to a DAU classroom location to attend courses. Students from more than 50 miles away incur temporary duty costs (travel, lodging, meals) that are paid by DAU. Until recently, class durations ranged from three days to 20 weeks. In response to downsizing and cost concerns in the mid-1990s, DAU developed a strategy to take advantage of emerging technologies and join the movement toward technology-based distance learning (commonly known as E-learning).

In the context of this study, a technology-based course is one that requires students and instructors to use the Internet and computer-based technologies to access and/or manage some or all aspects of the course. With contractor support, a unique Learning Management System (LMS) called the Virtual Campus was developed in 1998 in anticipation of hosting requirements for the to-be-developed Internet-based distance

learning courses. Since 1998, more than 18 technology-based courses (commonly known as on-line courses) have been developed by DAU, and more are planned. The number of graduates for each course ranges from several hundred to more than 10,500 students per year. Collectively, over 20,000 students graduate annually from these courses. The shift to on-line courses has significantly reduced the time students spend in the classroom environment, along with the associated costs.

Both mandatory and optional technology-based training courses are offered to over 130,000 Department of Defense acquisition workforce personnel in 11 career paths. Some courses are conversions from classroom courses, some are new courses designed specifically for the on-line environment, and some utilize a combination of new and existing material. The first courses were designed for Internet-based distance learning, with no physical classroom required. Later course designs, known as "hybrids," included both an Internet-based portion and an in-residence classroom portion. Table 1 summarizes the eight courses studied for this research project.

REVIEW OF DISTANCE LEARNING LITERATURE

The review identified success factors critical to managing the development of technology-based courses in the traditional university environment. General categories of success factors related to managing the development of distance education courses provided a basis for the development of a research protocol for

interviewing course managers at DAU. The success factors identified in the literature review were then compared with success factors identified during analysis of the DAU interview transcripts.

Due to the immense body of knowledge related to distance education, selection criteria for the search were very narrow, focusing on reports of success factors for the management of distance education development projects. The search favored empirical results from controlled studies where possible. Additional sources that reflected collection of data from experienced distance educators were also included.

> **"Both mandatory and optional technology-based training courses are offered to over 130,000 Department of Defense acquisition workforce personnel in 11 career paths."**

A summary of common problems related to innovation with on-line distance learning (Robinson, 2001) provided a useful method for success factor categorization. Based on the experience of 426 distance educators, Robinson classified distance education course issues related to innovation, leading to the four general categories of *resource availability, organizational issues, human resource capacity,* and *technology capabilities.* These four categories were used to organize success factors found in the literature.

RESOURCE AVAILABILITY

Resource issues figure prominently in the literature. Among the resources commonly identified as lacking during distance education course developments are time, funding, personnel, and a sufficient technology support infrastructure. Several authors

(Alexander, MacKenzie, & Geissinger, 1998; Brigham, 1992) cite the importance of instructional support services, as well as providing sufficient working time and realistic production deadlines, as success factors. Robinson (2001) points out that distance education projects are often underfunded as well as being too small in scope to be financially viable, suggesting that giving projects proper scope is necessary for success.

ORGANIZATIONAL ISSUES

Organizational success factors are often tightly interwoven with an organization's structure and culture, and may be difficult to implement in some situations, especially when introducing innovation into the organization. However, when the development team considers certain factors, distance learning project outcomes can be enhanced. For example, distance education courses require unique internal coordination and administrative practices (Robinson, 2001). Research shows that descriptions of processes for determining course content and the approval of that content must identify clearly the people to be included in the process (Brigham, 1992). In addition, the organization must provide appropriate technical support (Alexander, MacKenzie, & Geissinger, 1998) and consistent organization-wide strategies for the use of technology in teaching and learning (Bates, 2000). Wagner (1995) identified the need for adequate organizational learner and instructor support. Finally, consideration of the overall attitudes of administrators,

"Human resource capacity is tightly intertwined with other resource and organizational issues."

faculty, and staff toward the use of technology must be part of the course development (Brigham, 1992; Volery, 2001).

HUMAN RESOURCE CAPACITY

Human resource capacity is tightly intertwined with other resource and organizational issues. Several primary human resource issues were found in the literature. For example, development teams must produce quality materials and support the instructional requirements of a distance education environment (Brigham, 1992). Likewise, it is helpful to apply systematic and analytical methods of course design and development (Alexander, MacKenzie, & Geissinger, 1998); Wagner, 1995). The design and development needs require course developers to go beyond general conceptual planning and think through the details involved in a distance course (Robinson, 2001).

In an analysis of 104 Australian technology-based learning projects, Alexander, MacKenzie, and Geissinger (1998) determined that the instructional staff must address specific student needs, use the technology to enhance learning in ways not previously possible, use a sound and well-integrated instructional strategy, include learner support, and design assessments appropriate for technology-based delivery. A proper balance must be present between the capabilities of the instructional staff and the technical and instructional support staff (Volery, 2001), leading organizations with less technical support to invest additional resources in staff development.

TECHNOLOGY CAPABILITIES

A broad range of technological success factors are identified in the literature

reviewed. Availability of adequate technical support is mentioned repeatedly and is tightly interwoven with the resource, organizational, and staffing issues described above. Lopez and Nagelhout (1995) note three success factors for the use of technology in on-line education: reliability, quality, and richness. Alexander, MacKenzie, and Geissinger (1998) note numerous technology success factors including software testing, software development expertise (where relevant), copyright issue resolution, and student access to hardware and software. Bates (2000) noted that there is a tension between the need for student technology access and equity of access to higher education. Bates also made the interesting note that due to the high and recurrent investment cost in technology, the use of new technologies may not provide overall cost savings.

The literature indicates that not all course developments end successfully, and failures can often be traced back to poor understanding at some level of how to balance the factors discussed above, or even ignorance of some of those factors.

DATA COLLECTION AND ANALYSIS METHODS

The research design was largely qualitative and used guided interviews as the primary means of data collection. The interview protocol was designed to facilitate the exploration of the course managers' experiences and relate them to the general issues identified in the literature review. The interview protocol was validated with an initial interview conducted jointly by two researchers. A single researcher conducted all remaining interviews. All interviews were recorded and transcribed for the analysis.

The interview questions (see Appendix) were designed to provide field-based inputs from the eight DAU developmental course managers sufficient to allow the comparison of their experiences with the success factors identified in the literature. The interview questions were organized into three groups: stakeholder issues (organizational category issues), team-level issues in the development process (human resources issues), and course-level issues (resource availability and technology issues).

The interview method was face-to-face with follow-on contact for clarification. Data analysis included identification of 99 independent issues in the transcripts followed by organization of those issues into themes and then into candidate success factors. The course managers reviewed the results and a post-hoc analysis correlated the data with results of the literature review. As part of the post-hoc analysis, the DAU course managers reviewed the initial list of 10 most commonly occurring factors and their relative rankings. Based on their feedback, the initial list of 10 was reduced to eight by eliminating some redundancies.

> "The research design was largely qualitative and used guided interviews as the primary means of data collection."

RESULTS

The eight success factors, derived from the interview data, are described below:

1. *Effectively blending technologies* — This success factor includes researching and

analyzing available technologies and the most efficient mix of technologies, and considering methods of blending on-line and classroom delivery methods. Also included is understanding the impact of future changes driven by new technology. At DAU, entry-level courses typically require minimal instructor resources, while higher-level courses may have more interactive designs (e.g., blended (hybrid) on-line/classroom components), which require more resources.

2. *Technical configuration control* — This includes document version control, harmonization of design and development versions, and assurance of source documentation for all materials. Key challenges of configuration control for course developers were managing, tracking, updating and documenting the assignment of learning objectives to materials, creating test items based on the learning objectives and course content, and effectively managing developmental and production courseware releases. Real world policy changes must also be rapidly incorporated into courses, even as material is being developed, which adds to the configuration control challenge.

> **"Ineffective design strategies will not hold a student's interest in an on-line environment."**

3. *Project planning and management techniques* — This involves defining overall course requirements and learning objectives *before* developing the course design; making management tradeoffs to achieve the optimum balance between cost, schedule, and quality; developing baselines and metrics for the course development; continually tracking and monitoring the course's progress against those baselines; and making changes as necessary to ensure adequate progress and performance. These techniques are also critical to the success of any systems acquisition.

4. *Meeting student needs with instructional design strategies* — This success factor is particularly critical for distance learning or hybrid courseware. Ineffective design strategies will not hold a student's interest in an on-line environment. Data from the DAU interviews show that effective strategies include the use of problem-based and scenario-based training mechanisms along with storylines integrated across part or all of the course. Several courses employ a highly blended strategy that uses the on-line part of the course to prepare students to work effectively in the classroom as part of a team. Other important design factors include planning adequate student time for course completion, matching the course level with the students' expected level of preparedness, and providing efficient and usable resources to the students (some of these are not directly controlled by the course developer, but can often be indirectly influenced).

5. *Availability of Subject Matter Experts (SMEs)* — Ideally, full-time SMEs are dedicated to the project. This was a

big issue for the ACQ and PMT courses since they required SMEs from many different departments. The interview data indicate that there was chronic under-estimation of the SME time required in most of the eight courses studied. In several cases, the orientation of faculty supervisors toward traditional classroom instruction made them reluctant to provide adequate SME support for on-line development. Organizing faculty schedules to allow sufficient time for SME support while fulfilling numerous other commitments was also a constant challenge.

6. *Effective use of testing and evaluation* — This includes early usability testing, periodic demonstrations to organizational stakeholders, formative testing during design, and pilot testing by both instructors and students. Some courses faced major challenges because of unforeseen firewall issues and Internet access issues that did not show up in testing and were not adequately considered during the course development. Early test planning with updates as necessary and feedback of results into the ongoing development are important elements of this success factor.

7. *Staffing and teaming* — This includes ensuring a proper skill mix and a sensible ratio of workers to supervisors, a positive and supportive work culture, protecting the team from distractions, collocation of team members where possible (this included both government and contractor personnel), and careful selection of working team member combinations. Most DAU managers emphasized the importance of an integrated team with clearly defined and well-understood processes for decisionmaking and content reviews (both internal and external). Early inputs from all team members on critical design and content decisions and effective and timely communication methods were identified as important elements of team processes. Collocation of contractor and Government personnel, which enhanced communications efficiency, was very important for ACQ 201 and both PMT courses due to their tight schedules, complex storylines, unique designs, and integrated content.

> "Early inputs from all team members on critical design and content decisions and effective and timely communication methods were identified as important elements of team processes."

8. *Long-term technology support* — This success factor is similar to the challenges facing a program manager when considering interoperability and technology issues for a weapons system acquisition. It includes long-term technology planning, consideration of future requirements for interoperability of operating systems, ease of maintenance, and compatibility of courseware with future releases of plug-ins. These issues must be initially considered early in the development and revisited often as the course matures. Several of the DAU courses had to be partly redeveloped because of inadequate technology support.

For example, TST 101 was technically crippled when a new version of Flash software was widely distributed because an incompatible productivity tool was used during courseware programming. Because some of these early experiences, later courses used simpler, less volatile technology and had fewer problems in this area.

Once the eight DAU success factors were identified, each was rated by importance to each of the DAU courses included in the study. A rating of 1–5 was assigned to each success factor for each course studied, and the results were tabulated. Table 2 shows the relative importance of each of the success factors to each of the eight courses.

Analysis of the transcripts indicated that course-related factors such as complexity of content and design, and course length, as well as non-course factors such as the background and

Table 2. Impact of Success Factors by Course
Success Factor Ranking Matrix

Success Factors / Courses	Blending Technologies	Configuration Control	Project Management	Instructional Design	SME Availability	Test & Evaluation	Staffing/ Training	Long-term Technology*
Fundamentals of Systems Acquisition Management	3	5	5	4	4	5	4	4
Intermediate Systems Acquisition	5	4	5	5	4	4	5	3
Introduction to Acquisition Workforce Test and Evaluation	5	4	5	3	4	3	2	2
Basic Software Acquisition Management	3	5	2	3	4	5	3	3
Program Manager's Tools Course	4	4	5	3	5	4	5	4
Program Management Office Course	5	4	4	4	5	4	5	3
Fundamentals of Earned Value Management	5	4	4	5	3	3	3	5
Acquisition Business Management	5	4	4	4	2	3	3	3
Average Rating	4.4	4.3	4.1	3.9	3.9	3.9	3.8	3.4
Rank	1	2	3	4 (tie)	4 (tie)	4 (tie)	5	6

* Defense Acquisition Workforce Improvement Act (DAWIA)

personalities of key players, affected success factor rankings. Furthermore, changes in environmental elements during these course developments included:

- significant DAU organizational structure changes,

- management personnel turnover,

- increased LMS maturity and reliability, and

- increased levels of technical competence for both faculty and students.

All these factors influenced our results to some degree, but those effects are not specifically analyzed or addressed in this study.

DISCUSSION

The initial and post-hoc data analysis of the information provided by the eight DAU course development managers confirmed that the success factors in the literature were generally important to the DAU course developments. The most noticeable similarity between the DAU results and the literature reviewed is the overall categories of success factors. Both address issues related to human resources and technology. The literature focuses on organizational issues, while the DAU results focus more on program management issues. This may be an expected outcome when one considers the program management office (practitioner) background of the course development managers and the similarities of course development and program management processes.

The study also revealed some noteworthy differences between the literature and DAU success factors. A focus on financial resources was less evident in the DAU environment. One possible reason for this difference is that the level of funding available to a corporate university such as DAU may be generally sufficient for the outlined mission of the organization, whereas traditional universities may allocate fewer resources to their technology-based course developments. Another interesting difference is the DAU emphasis on course design and development process issues such as technical configuration control, availability of SME time, the use of an integrated development team, and effectively blending technologies. While some of the same issues are present in the literature, they tend to fall under the human resources category, suggesting the possibility that course design and development at traditional universities may differ from the semi-independent course development project teams common at DAU.

> "The most noticeable similarity between the DAU results and the literature reviewed is the overall categories of success factors."

RECOMMENDATIONS FOR DEVELOPERS OF TECHNOLOGY-BASED EDUCATION COURSES

Based on the DAU interview results and the distance learning literature, we developed a list of recommendations for managers of distance learning development programs. While these recommendations are

not all-inclusive, they supplement and in some cases parallel, recommendations found in the literature. They are particularly applicable to DAU, but should also constitute a relevant list for course developers in other environments as well.

1. If you determine that technology-based delivery for part or all of your course is appropriate, do not let a specific technology drive the course design. Instead, spend time up front determining educational objectives and developing an educationally sound instructional design. Follow this with market research to determine the most effective use of supporting technologies.

2. Allocate sufficient resources for effective configuration control throughout the course development process. This includes implementing processes for managing, tracking, updating, and documenting:
   - allocation of learning objectives to content,
   - assessments based on learning objectives and course content,
   - software versions, and
   - developmental and production courseware releases.

   Strong configuration control is particularly important for courses with dynamic content. Every team member must understand their role in configuration management and dedicate some of their time to configuration control.

3. Develop project management processes that support requirements-based

development. These processes include early definition of learning objectives and course requirements (prior to course design activities); baseline tracking systems that allow managers to track cost, schedule, and quality issues; regular reviews of progress; and adjustments to project plans and management objectives based on these reviews.

4. Use interactive, reality-based instructional techniques such as problem- or scenario-based learning, team-based training, and cases and stories. These techniques are decidedly more engaging to students than traditional presentation approaches, particularly in a distance learning environment, and can be used with a variety of blended delivery technologies.

5. Allocate sufficient subject matter expert time for distance learning development project. This study showed that the time necessary for SME review of materials is often underestimated, yet SME input is critical to the success of any course. Faculty SMEs often do not know how to provide effective, timely support for technology-based course developments unless they have experience; so be prepared to train SMEs and plan for a learning curve with inexperienced SMEs. Also, make SMEs integral to the development team. This is especially important for courses with integrated, multi-subject material or with content that must be integrated across different parts of the course (such as long storylines).

6. When testing distance learning environments, be sure that the test is conducted under conditions as close as possible to the actual production course environment. Often, problems go undetected during testing because the system was not stressed to the levels experienced by full student loads. A comprehensive test plan is important to eventual smooth operation of the course. Also, test often and at multiple stages of the course development. Be sure to test both the educational and technical aspects of the course, using both faculty and students.

7. Carefully control the staffing and development team arrangements. Critical issues include location of team members, managing distractions to the team, and implementing integrated product team strategies that allow all team members to provide inputs early in the development process. Effective multimodal communication is essential, especially if team members are not co-located. Establish and promulgate clear processes for ensuring timely submission and review of materials. Revisit processes periodically and any time performance metrics indicate poor results, and make appropriate changes based on team inputs.

8. When making technology decisions, be sure to consider the long-term viability of your choices. Expect changes in technology and availability of support, and try to be conservative in expectations of the future of new or novel technologies. Use the experiences of previous course developers to avoid pitfalls.

CONCLUSIONS

This study determined that success factors identified in the traditional higher education distance learning literature are relevant to managing the development of distance education courses at DAU. These factors fall into the categories of resource availability, organizational issues, human resource capacity, and technology capabilities. Funds availability was one factor emphasized in the literature, but not as evident in the DAU data. The DAU data also identified additional success factors that were important to the DAU course managers, but were not emphasized in the in other environments. These include a focus on technical configuration control, availability of SME time, the use of an integrated development team, and effectively blending technologies.

The study suggests that the professional education focus of DAU is partly responsible for the importance of the additional success factors identified, therefore the list of success factors may be applicable to institutions similar to DAU (in particular, corporate universities). Future research should elaborate the role of these additional success factors and clarify mechanisms for their

> "When making technology decisions, be sure to consider the long-term viability of your choices."

application in ongoing distance education development projects.

A list of recommendations for managers of technology-based course developments was created based on the DAU interview data. These recommendations should be applicable to institutions similar to DAU, and possibly are more generally applicable to other environments.

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APPENDIX
DATA COLLECTION PROTOCOL

Protocol Questions for Success Factor Research — These questions formed the basis of interviewer-interviewee interactions. Most of the questions were not asked directly, but were used as a resource to help guide the discussion.

Set I: Course-level decisions

    A. Describe how the course development project began.
        1. Who made the decision to include technology-based training?
        2. What/who influenced the decision?
        3. What constraints did that place on you?
        4. What initial decision led to important successes later in the project?
        5. What would have helped make the process smoother?

    B. Describe the resources (time, budget, personnel) available to you.
        1. Who determined the level of resources?
        2. Who managed resources?
        3. How appropriate was the level of resource for the project?
        4. What was most successful about the allotment of resources?
        5. What would have helped make the development work progress more effectively?

    C. Describe the development of the course design and structure.
        1. How was the main instructional strategy chosen? How were learning outcomes (objectives) selected?
        2. Who participated in these decisions?
        3. How did these decisions (or lack of decisions) influence development work?
        4. What would have made the process better?
        5. What worked best in the process?

    D. Describe the process for choosing the type of technology (or mix of technologies).
        1. How was the technology(ies) determined?
        2. How did this influence the development and design?
        3. What difficulties did you have with the technology during the course development process?
        4. What worked well?

Set II: Team structure, function, and purpose

    A. Group and team structure
        1. Describe the team composition.
        2. Were the team members good followers?

3. Did team members have adequate competence in their domain?
4. Describe the team's group process, was the team able to:
   a. Work under ambiguous conditions
   b. Tolerate ill-defined and emergent solutions
   c. Make decisions and live with constraints regarding solutions
   d. Be flexible to changing staff levels, personnel, schedules, tool availability, or other variables
5. How well was the team process supported during the project (time, resources, organizational structure)?
6. What technologies were used to support the team processes?
7. How was the team organized, and how was that organization maintained or adapted?

B. Group and team functions
   1. How was the project vision shared with the team (initial course design and prototypes)?
   2. What was the team involvement in definition of training problems?
   3. What was the role of the team in determination and updating/maintaining of learning objectives throughout the development process?
   4. What was the level of team involvement in selecting and designing/ organizing the instructional approach?
   5. What was the level of team involvement in selecting the technology and media?
   6. What was the team involvement in the vendor selection process?
   7. Describe typical working interpersonal relationships between team members.

C. Group and team objectives, goals, or purpose
   1. What was the role of the teaming arrangement within the greater organization (why use the teams, managing impact of new technologies on training organizations, etc.)?
   2. What was the scope of the teaming arrangement within the greater organization (involvement of upper management of both vendor and government, SMEs, developers, organization of the project)?
   3. What was the team involvement in quality standards for all stages of product development?

Set III: Stakeholder roles and characteristics

A. Describe the primary stakeholders for the government.
   1. Who are they?
   2. What requirements and constraints were delivered to you with the project?
   3. How did senior management convey their concerns and requirements?
   4. How did senior management influence the work you did on the project?

B. Describe the learners.
1. Who are they? What did you know about them at the start of the project?
2. How did you interact with them?
3. What role did learner evaluation play in the project?
4. How did learners influence the work you did on the project?

C. Describe colleagues (not mentioned under section two) that were important during the development of the project.
1. What were their roles?
2. How did you interact with them?
3. How did they influence your work?

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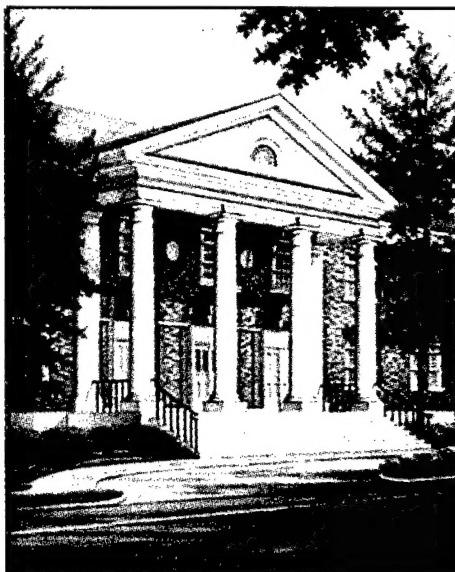
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